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Hazardous Waste Containers and Labeling Applicability of Department of Transportation Regulations

Moshman Associates, Inc, Bethesda, Md

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HAZARDOUS WASTE CONTAINERS AND LABELING:

APPLICABILITY OF DEPARTMENT OF TRANSPORTATION REGULATIONS

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16. Abstracts Moshman Associates conducted a study to determine the applicability of Department of Transportation Hazardous Materials Regulations for packaging and labeling of hazardous wastes. The study reveals that DOT regulations cover a narrower range of materials than does EPA authority under RCRA, Section 3001; DOT regulations generally cover materials with the more acute hazard characteristics. The study recommends that DOT container regulations be adopted by EPA for hazardous wastes. For those materials not regulated by DOT and certain DOT-regulated materials that are not particularly hazardous (e.g. tar liquid, jute-packing), the study recommends that specification non-reusable and single-trip containers and non-specification containers be authorized for use. DOT regulations for labeling and marking are also recommended for adoption by EPA. Materials not covered by DOT labeling requirements would be subject to regulation by a labeling system developed by EPA. The study concludes that existing data on long term container and label survivability are inadequate and the subject requires further study.

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ABSTRACT

Under Subtitle C of Public Law 94-580, Resource Conservation and Recovery Act of 1976 (RCRA), the Environmental Protection Agency is required to develop a comprehensive approach to and promulgate standards for hazardous waste generators, transporters, and receivers; further the Act requires that regulations be consistent with those of the Department of Transportation for hazard materials. This study examines existing DOT regulations, the opportunity to expand them to include hazardous commodities proposed to be regulated but not now included in DOT regulations and analyzes the packing, labeling, marking, and shipping paper requirements for different classes of hazardous wastes.

Specific recommendations include amendments to title 49 CFR to add authorities requisite for the regulation of EPA defined wastes, to permit resource and energy conservation through reuse of containers, to exempt small quantity shipments, and various other requirements. DOT prescribed labeling and marking were found suitable for most acutely hazardous wastes; for less hazardous commodities an "E" warning label and a correlated container-shipping paper identifying system is recommended.

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David G. Abraham, Vice President of Moshman Associates, Inc., was the contractor's Project Director, and James Winchester, Jr. served as principal research assistant. Lawrence W. Bierlein, Esq., assisted by his special assistant Gordon Rousseau, performed all legal and regulatory research and analyses.

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HAZARDOUS WASTE CONTAINERS AND LABELING: APPLICABILITY OF DEPARTMENT OF TRANSPORTATION REGULATIONS

I. Introduction and Scope of Study

A. Background. In July of 1977 the United States Environmental Protection Agency, through its Office of Solid Waste Management, engaged Moshman Associates, Inc., in association with the law offices of Lawrence W. Bierlein, to prepare an analysis of the applicability of the Department of Transportation's (DOT) regulations for the transportation, marking, and labeling of hazardous materials to hazardous wastes.

This study was motivated by the provisions of Subtitle C - Hazardous Waste Management of Public Law 94-580, Resource Conservation and Recovery Act of 1976 (RCRA), signed into law on October 21, 1976.

RCRA mandates a comprehensive Federal-State-local approach to all aspects of waste management, including resource conservation and recovery, land disposal of municipal and industrial wastes and authorizes a new regulatory program for hazardous wastes. Under Subtitle C, EPA is required to develop and promulgate standards for hazardous waste generators, shippers, transporters, and receivers. In addition EPA is required to develop criteria and a list to define what are hazardous wastes.

Current DOT regulations under the Hazardous Materials Transportation Act of 1974 (HMTA) may have the potential to be expanded to fully or partially meet the mandate of RCRA.

In particular, the Act requires that regulations developed under Subtitle C of RCRA be consistent with the requirements of HMTA and the regulations thereunder. In addition, RCRA authorizes EPA to make recommendations to DOT respecting regulations for hazardous wastes under HMTA and for the addition of materials to be covered by that Act.

Authority for the regulation of hazardous waste transportation is contained in both HMTA and RCRA. The basic distinction in these two laws is embedded in their respective foci on what is to be protected. HMTA is concerned with the protection of public safety, health, and property during the loading, unloading, transportation, and storage incident to transportation of hazardous materials. This Act requires the Secretary of Transportation to designate materials as hazardous upon finding that the transportation of a particular quantity and form of material in commerce may pose an unreasonable risk to health and safety or property. The materials designated as hazardous may include, but are not limited to: explosives, radioactive materials, etiologic agents, flammable liquids or solids, combustible liquids or solids, poisons, oxidizing or corrosive materials, and compressed gases.

Under Subtitle C, RCRA is concerned with the protection of public health and the environment from improper hazardous waste management during transportation, treatment, storage or disposal. Hazardous waste as defined by RCRA is a solid waste, or combination of solid wastes which, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may cause, or significantly contribute to an increase in mortality or an increase

in serious irreversible, or incapacitating reversible, illness, or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of. RCRA defines "solid" waste to include solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, community activities, and, with some exception, agricultural operations. The Act directs EPA to take into account when designating hazardous wastes, toxicity, persistence and degradability in nature, potential for accumulation in tissue, and other related factors such as flammability, corrosiveness, and other hazardous characteristics.

For the transportation of hazardous wastes under RCRA, Section 3002 requires the Administrator to develop standards for generators, i.e., the shippers of hazardous wastes, concerning labeling practices for any containers used for storage, transport, or disposal that will identify accurately such wastes, use of appropriate containers, and use of a manifest system to assure that all hazardous waste generated is consigned for treatment, storage or disposal to a permitted hazardous waste management facility.

Under Section 3003, EPA is directed to develop standards for transporters of hazardous waste concerning recordkeeping, transportation of hazardous wastes only if properly labeled, compliance with the manifest system and transportation of all the hazardous wastes to the designated permitted facility. In addition, the Administrator is considering the development of standards for the acceptance of hazardous waste for transport, loading and stowage

of hazardous wastes, notification in the event of a spill and spill reporting, marking and placarding of vehicles, and notification of the transportation of hazardous wastes.

Preliminary EPA analyses of the requirements under Sections 3002 and 3003 of Subtitle C indicated that the requirements of HMTA are overlapping with RCRA, specifically, in definition of hazardous material (waste), labeling, placarding, packaging, manifest (shipping paper), spill notification and reporting, and loading and stowage. In addition, HMTA has provisions for the development of standards concerning recordkeeping and registration. It thus became obvious that prior to the promulgation of standards and regulations by EPA, due consideration must be given to the applicability of currently existing standards under HMTA. This need is further emphasized by the beforementioned RCRA mandated requirement in subsection (b) of Section 3003, Coordination With Regulations of Secretary of Transportation. Referring to the regulations to be promulgated by EPA for transporters of hazardou wastes, and applying to such materials as are subject to HMTA, this subsection states:

> "the regulations promulgated by the Administrator...shall be consistent with the requirements of such Act (HMTA) and the regulations thereunder."

Further, EPA is authorized to recommend to DOT additional materials to be included in DOT's regulations and for changes or additions to that agency's regulations under HMTA.

B. Scope of Study. The study's scope, as defined in the referenced contract, consisted of three tasks as briefly summarized below.

1. Task I. Focus was on the durability of specification containers, especially after their exposure to hazardous materials. The contractor was required to review prior study reports and to conduct interviews with knowledgeable persons respecting this study focus. The purpose of this task, in the main, was to collect, summarize and present in a cohesive document the accumulated knowledge of the "shelf life" of specification packaging or, put differently, the deterioration over time of DOT authorized packaging as induced by their exposure to the hazardous materials contained in such packaging.

Excluded from this research endeavor was the influence of external or environmental factors on the durability of specification containers. It might be noted here parenthetically that a dearth of empirical data and knowledge were found to exist on the general topic of container longevity or durability over time.

2. Task II. In this portion of the research, the applicability and inapplicability of existing DOT hazardous materials regulations and standards to hazardous wastes were to be determined. While EPA has not developed final definitions for what are hazardous wastes, required under Section 3001, Identification and Listing of Hazardous Waste, preliminary definitions for the following types of wastes were furnished to us: reactive, corrosive, flammable, infectious, and toxic.

Accordingly, the research undertaken pursuant to this task considered the applicability of DOT regulations in context with the preliminary definitions provided, with emphasis on criteria

including (1) the degree of long-term containment, identification, and visibility afforded by the DOT regulations, and (2) the various ways in which hazardous waste containers are likely to be used. These were anticipated to include:

- transportation of waste to a treatment site;
- transportation of waste to and containment at a storage site;
- transportation of waste to a disposal site.

It should be noted that containment after disposal, first believed to be an essential consideration, was not considered in this study. It was determined by EPA officials that disposal was to be interpreted as analagous to zero containment within the shipping container. Contrarily, consideration was given to long-term containment prior to disposal or other disposition of the hazardous wastes then stored in shipping containers.

3. Task III. In this last task, the contractor was required to examine existing and proposed marking and labeling systems for hazardous materials. Further a marking or labeling format for wastes was to be proposed with the guidelines that such format be supplementary to existing DOT label requirements.

Again, consideration was given to the different logistical functions inherent in the removal of hazardous wastes from generator's premises, as detailed under Task II, above.

II. Summary of Findings and Recommendations

The research, analyses and assessments performed by the Contractor have resulted in the major findings and recommendations as summarized below.

- EPA's tentative definitions for hazardous wastes, subject to regulation under Section 3003 of RCRA, are broader than DOT's hazardous materials definitions under HMTA. Thus EPA contemplates including materials in its scope of regulated commodities that may be less acutely hazardous, but that may pose the threat of environmental damage.
- DOT's current regulations for specification packaging are believed to be adequate for transportation of wastes regulated by DOT.
- DOT's regulations are designed to cover a wide spectrum of transportation characteristics including transportation by air. Wastes are not likely to be transported by air nor will they normally be subjected to movements over long distances and by multiple modes. While DOT's standards for packaging must necessarily encompass the full range of conditions likely to be encountered by hazardous materials in transit, e.g., thermal stresses, pressure changes, etc., packaging standards for all but the most acutely hazardous wastes could be less rigid. This would be consistent with RCRA objectives to conserve valuable material and energy resources.
- Except for explosives, shippers are responsible for classifying the materials shipped. The Bureau of Explosives, as an agent of the U.S. Government, classifies a commercial or nongovernmental material as an explosive. ERDA and the

Army Materiel Command have comparable authority for certain special and military explosives.

- DOT regulations grant exemptions from packaging, labeling, and marking requirements for small quantity shipments.
- DOT and HEW regulate certain infectious materials, essentially certain etiological agents. DOT does not prescribe specific packaging except for some performance criteria; HEW's packaging specifications deal mainly with quantity limitations rather than the container itself. The majority of materials preliminarily defined by EPA as infectious wastes are not currently covered by DOT's etiologic agents regulations. DOT docket HM-142 is a rulemaking proceeding which seeks to establish the adequacy of current packaging, labeling, and marking regulations.
  - It was determined that existing data and knowledge are lacking in the area of long-term container survivability. This topic is of concern to EPA, for it is feasible that waste-containing packaging will have to be stored at zero discharge conditions for extended time periods.
  - DOT prescribed container labeling and marking are appropriate for most high hazard DOT regulated wastes, but certain less hazardous DOT regulated wastes may not require strict compliance with current DOT shipping name marking requirements.
- The DOT placarding system aims at communicating the fact that a hazardous material is being transported which can be an acute and immediate hazard to people in the immediate vicinity of the vehicle. Placarding for transportation of EPA regulated wastes not also regulated by DOT was found not to be required.
- DOT label specifications do not particularly reflect the long-term survivability and legibility of the label and its

inscriptions; the objectives of DOT's standards reflect conditions and duration of normal transportation. EPA's objectives include longer time periods and storage conditions which can affect labels' integrity.

- Recommendations respecting packaging specifications reflect three transportation purposes applicable to regulated wastes. These are from the generators' facilities to (1) treatment plants, (2) storage facilities, and (3) disposal sites. Recommendations also reflect four levels of hazards, namely, (1) most acutely hazardous to people, (2) less acutely hazardous to people, (3) still less acutely hazardous to people but representing hazards to the environment, and (4) health hazard not presently regulated by DOT. The thrust of the contractor's detailed recommendations is along these lines:

  - For the most hazardous wastes, DOT packaging is appropriate.

  - For the less acutely hazardous wastes, DOT packaging could be relaxed to permit reuse of specification containers for which such reuse is now prohibited or refurbishing and testing is required. This would also apply to wastes in the third group; for both, performance oriented standards are preferable to specification packaging requirements.

  - For wastes not now regulated under DOT's definitions, in particular etiologic agents, carcinogens, mutagens, and genetically active materials, DOT regulations for comparable hazards should be applied.

- Actions recommended to be taken to insure compatibility with DOT regulations and enforcement, to attain the conservation objectives and avoid confusion inhibiting voluntary compliance, include petitioning DOT to:

  - Require all wastes in the most hazardous group to be packaged in conformance with Part 173 and 178 of 49 CFR;

- Revise current regulations to permit new or used (not reconditioned) including non-reusable and single trip specification containers for the transportation over distances of less than 500 miles by one motor carrier for flammable liquids and solids, corrosive liquids, Class B explosives, oxidizers, and Class B poisons;
- Revise Part 173.24 to permit utilization of specification and non-specification packaging suitable for the transportation of less acutely hazardous wastes;
- Revise DOT regulations to encompass etiologic agents.

- Establish a general rule in EPA regulations to adopt DOT's regulations, as proposed to be revised, for all RCRA defined wastes which also meet DOT's hazard definitions.
- Establish a general rule in EPA regulations to adopt DOT's general performance packaging requirements as contained in 49 CFR 173.24 subsequent to the revisions proposed.
- Recommendations for labeling and marking regulations reflect EPA's mandate, as distinct from DOT's, authorizing the regulation of recipients of hazardous wastes. Further, these recommendations are mindful of DOT's regulations applying to wastes posing the greatest threat of bodily harm and property destruction. For these, DOT's "alert" signals should continue to apply, and to that end, it is recommended that EPA adopt the Title 49 labeling requirements by reference to wastes which pose hazards of flammability, corrosion, etc. during transportation.
- For non-DOT regulated wastes, in general the less acutely hazardous materials, it is recommended that a single version warning label be prescribed. A format for such label, dubbed as the 'E' label has been developed. A

limited quantity exception is recommended for application to containers otherwise required to bear the 'E' marking or label.

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- Where DOT regulations do not require name of contents marking, it is recommended EPA not require it either. Further, that EPA petition DOT to remove the requirement for name marking on DOT labeled containers bearing wastes in less hazardous categories.
- Adopt regulations requiring the removal or obliteration of markings on previously used containers which have not been refurbished.
- Development of a system to pair containers and their shipping documents is recommended by one or several methods of common identifiers, most likely numeric or alpha-numeric. Such systems need not be detailed in regulations; rather, its particulars should be the responsibility of licensed disposal site operators. Regulations would require the implementation of a system(s) and that it meet, at minimum, the requirements of 49 CFR 172.304 in respect of the durability and legibility of the container marking.

III. Hazardous Waste Specification Packaging

A. Transportation, Storage, and Handling Conditions Underlying DOT Packaging Standards

1. Present Standards. DOT packaging specifications have been designed to protect hazardous materials from hazards normally encountered during transportation, storage, and handling. The regulations set forth a basic requirement that the package must withstand the normal environmental transportation conditions to which it will be subjected. (See 49 CFR 173.24.) The DOT regulations contain many tests designed to evaluate the durability of packaging with respect to its ability to reliably protect its contents during this transportation.

Although transportation is normally understood to be that phase in which the package is in place within a vehicle whose intended purpose is to transport, the DOT regulations encompass a much broader connotation of "conditions normally incident to transportation," including storage and handling as well as actual movement.

Many different physical loads are imposed on packaging during transportation. DOT generally summarizes these into vibration, shock, acceleration, stacking, environmental temperature and pressure changes. Vibration is found in all modes of transportation but is most severe in ground vehicles and air transport vehicles. The most severe shocks are those encountered in rail car bumping operations. The only acceleration loadings which

are significant enough to consider occur mainly in aircraft maneuvers, particularly in emergency maneuvers. Stacking considerations are particularly important in warehousing phases and in ocean transportation. Thermal stresses can arise in all modes of transportation, but in air transport the changes can be rapid enough to subject a package to thermal shock. Finally, pressure changes that occur from altitude variations in air transport can severely strain the adequacy of gaskets and sealants used in packaging. The problems of pressure changes are specifically addressed in the DOT regulations with respect to air transportation.

Since wastes are generally not transported by air, the considerations of acceleration and thermal stress (dynamic) and pressure change are not developed any further for the purpose of this study. It is important to note, however, that all these considerations enter into the DOT standards for design of packaging. A package is expected to withstand the normal conditions of transportation that may be encountered in surface, air, and water transportation, including storage and handling. These include rough handling (vibration and stacking), dropping, and internal pressure.

The Department of Transportation has studied the strict transportation phase extensively. In a contract let to the General American Transportation Corporation in 1971, two surveys were conducted. The first was a survey of environmental conditions incident to the transportation of materials, the second a survey of test methods currently used for simulating the

transportation environment. Although the studies included some testing which is not generally used or referenced in the DOT regulations, it is important to note that DOT has been taking the environmental conditions that packaging is expected to encounter into account, and has done studies of the relationship of the packaging prescribed to these conditions of transportation. The General American Transportation Corporation study in this respect may be referred to generally as a quantification of some of the DOT guidelines in terms of developing their bases and adequacy with relation to currently authorized packaging. ("A Survey of Environmental Conditions Incident to the Transportation of Materials", F.E. Ostrem, et al., General American Transportation Corporation, October 1971, NTIS PB-204 442.)

At this point it is important to note that the DOT Hazardous Materials Regulations have been developed on a combination of empirical test results and experience during actual transportation. Although this practice has generally proven adequate and has provided specification containers that are successful, it makes quantitative evaluation of the quality of DOT packaging very difficult. It further makes it extremely difficult to talk in terms of modifying this packaging on the basis of known quantitative elements.

Studies that have been conducted under DOT contracts have been designed to give the DOT a base from which to develop performance packaging. ("Development of Performance Oriented Specification for Drums and Pails Used for Packaging of Hazardous Materials for Transportation", C.E. Fridinger, et al., Naval

Surface Weapons Center, December 1974, NTIS PB-240 647.) This base has been developed in conjunction with review of existing government standards, DOT specification requirements, and military specifications. ("A Survey of Test Methods Currently Used for Simulating the Transportation Environment", Phase II, A.N. Henzi, General American Transportation Corporation, April 1971, NTIS PB-202 728.) There is no direct or intended relationship between these various standards. Each standard "borrows" a few requirements and specifications from others. This adds to the difficulty in scientifically assessing DOT packaging requirements. The DOT testing requirements are stated so generally that variations that may be introduced during the testing can significantly alter the results. It must be said, however, that industry's incentive to get the product to destination has prevented these variations from resulting in unsatisfactory transportation experience. This also explains the great variation one may find between two identically marked DOT specification containers. and the experience that one obtains during transportation of materials in two such containers.

It would be erroneous to assume that a DOT specification is a rigid enough standard to guarantee similarity in experience between containers. Similarity is limited to a few tightly specified, detailed requirements of the DOT specifications. Beyond this point, implementation of quality control measures is left to the container producer. The frequency with which the DOT tests are required to be conducted can hardly be considered a quality control program in itself. They take the form

of a monitoring system that generally oversees the adequacy of the packaging. There is no doubt, therefore, that the real integrity of the packaging in many respects is left to the designer. The designer's ingenuity may go beyond the design of the package and may include the manner by which the tests are run. DOT packaging specifications are, in fact, general guidelines that enable a package manufacturer to develop an adequate package for transportation, but the specifications are not the final measure of the qualities of the packaging.

The final measure is the capability of the packaging to deliver the goods safely to destination. That measure is a combination of the quality of the packaging that is sold to the purchaser and the reasonable controls that must be exercised in the handling and transportation of packaging. A DOT package is not designed to take all the punishment that may be meted out to it. It is designed to withstand what the normal transportation environment presents to it. This environment supposes that certain care will be taken in the handling of the package. Consequently, human error often can lead to package failure. For example, the fork lift operator who drives the fork lift into the side of a drum causes a rupture. Drums are not designed to withstand this impact. Safe transportation of hazardous materials requires a combination of adequate packaging and controlled handling. The DOT philosophy in packaging or, indeed, any philosophy in packaging of goods other than high level radioactive materials, has not been to design a package that will withstand a maximum credible accident.

The result of all this, therefore, is that any study designed to assess DOT packaging criteria must draw on a combination of historical knowledge, experience, and the specifications as they are written. From a scientific standpoint, it is the reason why the General American Transportation Corporation survey of test methods currently used for simulating the transportation environment did not include DOT specification test requirements by name. The DOT test requirements are not given in sufficient detail to constitute a scientific or technical standard. Many of the specifications, for example, prescribe a drop test requirement, but the equipment used to lift the test container to its drop elevation, the environmental conditions of the test, the specific angle of drop, etc., are not prescribed by DOT. Most scientific and technical standards would prescribe such details to minimize variations in test results from test to test, test location to test location, tester to tester, and container to container. On the basis of the DOT general test requirements, and the need for standardization, industry and the military agencies have developed standards for testing packaging which are very adequately covered in the General American Report. With the report then, it is possible to evaluate what the typical DOT packaging is expected to withstand. It is on this basis that the following statements with regard to a quantified transportation environment are made:

Vibration. The DOT vibration tests, although not always expressed very clearly (the best expression is in new DOT Specification 35, 49 CFR 178.16), intend that packaging will be

placed on a platform that has a vertical, double amplitude (peak-to-peak displacement) of 1 inch. The tests must be performed for one hour at a frequency that causes the package to be raised from the vibrating platform to such a degree that a sheet approximately 1/16th inch thick can pass between the bottom of the package and the platform. In the packaging industry, this type of test is often referred to as a "bounce" test, in contrast to other types of vibration tests referred to as cycling and resonance tests.

It is interesting to note that the cycling test is the clearest attempt to simulate the transportation environment as it relates to vibration. This is because the test requires a vibration source that allows adjustment of amplitude as well as frequency, whereas the source required for the bounce test is of fixed amplitude. A resonance test is an entirely different type of test of much greater sophistication and has not yet been recognized by the DOT regulations. The resonance test consists of a single frequency sweep to identify the frequencies at which the test item exhibits resonance. A package generally is fitted with one or more accelerometers and resonance is indicated by a peaking of the ratio of package acceleration to table acceleration, as the frequency is slowly swept.

Since the DOT vibration test (bounce test) generally is run in only one axis, the packaging community understands that a one-hour test is equivalent to 4,000 miles of surface transportation for the package in that orientation. One should keep in mind that this guideline is extremely general. The DOT rules,

for example, do not take humidity into account for packages that might be affected by such conditions, or the vibrations experienced in overloads which would be representative of stacking in vehicles. The equation of testing conditions and time length of transportation is at best a marriage of experience and general scientific bases, but it would be erroneous to assume that the testing is directly relatable to time in transportation. It is a reliable indicator and has been used as such by the DOT and, one must add, successfully. Scientists generally consider the bounce test to be a very crude test, but it nevertheless has received wide acceptance. Packaging engineers readily admit that bounce tests have proved entirely acceptable in estimating the endurance of a package subject to transportation vibrations. One military study, in fact, found that there was remarkably good correlation between results in bounce tests and performance in vehicle tests on the Belgian Block Course in Aberdeen Proving Ground. The bounce test is truly a damage equivalency test and, although it is difficult to quantify, it nevertheless reveals much about the durability of the packaging.

Drop Testing. The most frequent test referenced in the DOT regulations is the drop test. The drop test cannot be directly related to time in transportation, since under any circumstance of distribution, a four foot drop is a distinct possibility. The height of 4 feet was chosen on the basis of height of handling equipment, rail cars, vehicle tailgates, lift of boxes by

personnel, etc. It has served well as a general guide to the rough handling and shock that a package can withstand during transportation.

It is a test that should not be required in the hazardous waste context, since it is a destructive test and, presumably, packaging that would be exposed to such testing could not again be used. Considering packaging available to a generator of waste, and recognizing that a certain proportion of the packaging that could be used may come from many different sources, it would be difficult to use drop criteria to evaluate waste containers. However, noting that packaging used for initial transportation of hazardous materials generally is required to be capable of withstanding a 4-foot drop, it would seem reasonable to authorize reuse of DOT specification packaging for disposal of wastes that are DOT-regulated, or use of nonspecification packaging that can be shown to have been built to a standard requiring a 4-foot drop evaluation. For wastes that currently are not regulated by DOT, it is this contractor's opinion that the drop test is not a necessary criterion to evaluate the suitability and adequacy of a packaging for transportation purposes.

Hydrostatic Testing. This is another test found in the DOT regulations that is very common. Like the drop test, it also can be a destructive test. It is not a test that we believe need be conducted on packaging to be used for EPA-defined hazardous wastes not currently regulated by DOT. As in the drop test, waste that is presently regulated under the DOT Hazardous Materials Regulations would need to be packaged in

DOT packaging that has withstood hydrostatic testing, at least initially, as a type test.

Leak Testing. The DOT regulations regularly require leak testing for packages that are intended to contain hazardous materials, particularly liquids. A few of the packages designed for solids are also required to be leak tested. Leak testing normally is done at a pressure rate substantially lower than hydrostatic testing. Typically, such tests are run in the range of 5 psig to 15 psig. DOT generally does not specify the time over which the container must be leak proof during the test. This test is intended to be a production line test and, under some circumstances, is done quite quickly. This test is simply to evaluate the integrity of the packaging when it is ready for use.

2. Differences in Transportation Characteristics, Hazardous Materials, and Hazardous Wastes. The preceding section contains a detailed discussion of the transportation characteristics underlying DOT's packaging regulations. It was pointed out that these assumed characteristics, as manifested in the required types of tests and standards, encompass the possible spectrum of transportation modes and the exposures incidental to each of them. We must now consider to what extent these maximum transportation characteristics might be different for hazardous wastes.

First, as noted in reference to acceleration, thermal stress, and pressure change tests, it is quite unlikely that substantial volumes of waste would be transported by air. Hence, the rigors of that mode need not be considered for waste packaging specifications.

Second, it is likely that two other conditions will not apply to wastes, except possibly for some bulk movements. These conditions are intermodal shipment, i.e., the transfer of packaged wastes from one mode of transport to another, and transportation over extended distances. Though we have not conducted any specific research to identify typical transportation characteristics for different categories of hazardous wastes--such research we understand was undertaken by another contractor--we are aware of the validity of the aforementioned exclusions.

Further, it is reasonable to project that, in general, packaged waste will move only over the least possible distances. This ascertainment stems from purely economic considerations. Any commodity without a minimal commercial value will always be disposed of at the authorized place nearest that commodity's generator. Likewise, if the waste packages are consigned to private or common carrier trucking, it is most unlikely they would then be reconsigned or transferred to rail or water transportation. Since transportation by rail for short distances, generally less than 250 km to 300 km, is uneconomical compared with truck transportation, it is also unlikely that rail transportation would be a frequent mode for waste shipments.

An exception to these foregoing statements is the transportation of wastes in bulk, as would be the case for sewer sludge or large quantities of flammable solid lubricants, acids used in etching or tanning processes, or the like. These types of wastes could, and some do now, move over considerable distances in tank cars, trucks and barges. For some of these movements,

intermodal transfers such as from tank car or truck to tank barge occur. In these cases, single mode and intermodal transportation in bulk, the rigors of transportation can be quite comparable to those underlying the DOT specifications. It would therefore be reasonable to suggest that DOT standards be applied to hazardous wastes transported in bulk.

For wastes transported in smaller packages, however, the greatly reduced exposure to perils of vibration, shock, acceleration, and stacking suggests the appropriateness of somewhat lesser quality containers as compared with those DOT has found suitable for intermodal and international transportation of hazardous materials.

The desire to utilize containers conforming to less rigid standards should be remembered as an important RCRA objective. Section 1003 of the Act, "Objectives" states: "The objectives of this Act are to promote...and to conserve valuable material and energy resources...." Clearly, if this objective were to be applied in respect of the waste materials only and not also the packaging prescribed for them, this would tend to negate or at least severely reduce the conservation objectives of this legislation. In sum, the differences in transportation characteristics here discussed provide an opportunity to consider and eventually specify containers which are less costly for the user and which take less material and energy to manufacture.

B. Evaluation of DOT Packaging Requirements and EPA Hazardous Waste Definitions. In order to adequately evaluate the adequacy and

propriety of DOT packaging requirements as they would apply to EPA defined hazardous wastes, one must first understand the relationship between EPA's categories and the existing DOT hazard classifications. Following is such an analysis including the DOT specification packagings required for the DOT regulated hazardous materials which would fall within each of the five EPA categories (as they appeared in preliminary definitions received from EPA in August 1977) of reactive, corrosive, flammable, infectious, and toxic wastes.

1. Reactive Wastes. The draft definition of reactivity made available to us includes any waste having the following properties:

(a) Wastes which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also wastes which may react violently with water, which may form potentially explosive mixtures with water, or which generate toxic fumes when mixed with water.

(b) Wastes which in themselves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.

(c) Wastes which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.

The EPA draft definition of reactive waste covers some materials that would appear to be regulated by the Department of Transportation as explosives, as well as certain materials that DOT would classify as flammable solids. The DOT regulations in 49 CFR Parts 100-189 define regulated classes of

materials and, in addition, prescribe the classifications of certain materials by name. In other words, the DOT regulations with regard to classification are both generic and specific.

For DOT purposes an explosive is defined as "any chemical compound, mixture, or device, the primary or common purpose of which is to function by explosion, i.e., with substantially instantaneous release of gas and heat," unless the compound mixture or device is otherwise specifically classified in Parts 170 through 189 of the DOT regulations. In reviewing this definition it is important to concentrate on the words "the primary or common purpose of which is to function by explosion." This definition implies that although a material may explode it may not be an explosive. In other words, the DOT regulations only define and classify materials as explosives which commonly are intended to serve as explosives. If a material explodes, it may be intended to explode or that reaction may not be intended at all. The matter of intent or determination of the primary or common purpose of the article is an integral part of the DOT explosives classification. This is pertinent to the EPA description of reactivity which is linked more directly to the properties of the material than its intended reaction. It would appear that the draft EPA definition of reactive materials would cover a substantially broader category of material than the DOT explosives definition, if only on the basis of this delineating criterion of intent or common purpose of the material. Thus, if a waste generator has material that he intended or for which the common purpose was to serve as an explosive and he is

discarding that material, that explosive waste should be classified as a DOT explosive and should be packed, marked, and labeled as such in transportation. If, however, material is not intended or does not bear the primary or common purpose of functioning by explosion but merely as a material that may explode, it will be an EPA reactive waste but it will not be regulated as an explosive by the U.S. Department of Transportation. (DOT is well along in its procedure to alter and quantify the definition of explosive materials but, as of this writing, the definition remains generic, hinged to the intent of the maker or the common purpose of that material.)

Before describing those materials DOT would regulate as explosives, it is essential to review the general sections of the DOT regulations of explosives, particularly with regard to "forbidden" explosives. If a material is classified by the U.S. Department of Transportation as an explosive it may not be entered into transportation, or is "forbidden," if it is one of the following:

(a) an explosive composition that ignites spontaneously or undergoes marked decomposition when subjected for 48 consecutive hours to a temperature of 75°C. (167°F);

(b) an explosive containing an ammonium salt and a chlorate;

(c) liquid nitroglycerine diethylene glycol dinitrate, or another liquid explosive not specifically authorized by DOT;

(d) an explosive condemned by the Bureau of Explosives (of the Association of American Railroads);

(e) a leaking or damaged package of explosives;

(f) condemned or leaking dynamite unless repacked by a competent person in the presence of or with the authority of the Bureau of Explosives;

(g) firecrackers, flashcrackers, salutes, or similar commercial devices which produce or are intended to produce an audible effect and contain in excess of 12 grains of explosives each;

(h) pest control bombs, the explosive content of which exceeds 18 grains;

(i) any firecracker type device without respect to explosive content which, on functioning, is liable to project or disburse metal, glass, or brittle fragments;

(j) fireworks that combine an explosive and a detonator or blasting cap;

(k) fireworks containing ammonium salt and a chlorate;

(l) fireworks containing yellow or white phosphorous;

(m) fireworks or firework compositions that ignite spontaneously or undergo marked decomposition when subjected for 48 consecutive hours to a temperature of 75°C. (167°F.).

(n) fireworks condemned by the Bureau of Explosives;

(o) toy torpedoes in excess of 7/8 inch outside dimension or toy torpedoes containing a mixture of potassium chlorate, black antimony, and sulfur with an average weight of explosive composition in each torpedo exceeding 4 grains;

(p) toy torpedoes containing a cap composed of a mixture of red phosphorous and potassium chlorate exceeding an average of ½ grain per cap;

(q) fireworks containing copper sulfate and a chlorate;

(r) loaded firearms; and,

(s) "new" explosives and explosive devices that are not yet classified by the Bureau of Explosives.

Under 49 CFR 173.86, the Bureau of Explosives as an agent of the U.S. Government is the only authorized agency for determining the classification of a commercial or non-governmental material as an explosive. Every "new" explosive as that term is defined in Section 173.86 must be classed and approved by the Bureau of Explosives, or by ERDA or the Army Materiel Development and Readiness Command for certain ERDA and military explosives. This is an exception to the general DOT rule that the shipper of the material is the party responsible for its classification.

In addition to forbidding the shipment of certain explosive materials in 49 CFR 173.24, DOT prohibits the shipment of any material in any packaging if, under conditions normally incident to transportation, there would be a significant release of a hazardous material to the environment; the effectiveness of the packaging as a transportation container would be reduced; there would be a mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure or through an explosion, significantly reduce the effectiveness of the packaging; or the materials might react with packaging to the end that there might be significant chemical or galvanic reaction among any of the materials in the packaging.

DOT subgroups its explosives into Class A, B, and C explosives. Class A explosives are those with a detonating or otherwise maximum hazard. Class B explosives are those that are

considered deflagrating or of a flammability hazard, while Class C explosives are those which pose a minimum hazard.

Class A explosives are defined according to type in 49 CFR Section 173.53. In addition, that section describes certain materials according to their functions, such as rocket ammunition or ammunition for cannon. The types of explosives described in that section relate to the quantity of explosive, the form of that material, and the drop or impact it takes to detonate the material according to certain tests prescribed by the Bureau of Explosives and the impact of certain blasting caps. Articles which would be classified by the Department of Transportation as Class A explosives are also likely to be regulated directly as explosives by the Alcohol, Tobacco and Firearms Division of the Department of the Treasury. Between the regulations of DOT and the Treasury, which governs the sale, transportation, storage and use of explosives, it is likely that any waste generator with an article classified by DOT as a Class A explosive would be licensed by the Treasury and would be under very strict limitations on the manner and location in which he may dispose of those explosive materials. Judging by the nature of DOT's definition of Class A explosives, the controls imposed on those explosives under the Organized Crime Control Act administered by the Treasury, and the apparent aim of EPA in drafting a definition of reactivity, it is unlikely that Explosive A waste materials will be encountered and we do not believe it necessary to consider the appropriate packaging of those materials for disposal. Appendix A to the preliminary EPA reactivity definition,

for example, citing 6 incidents of explosions leading to injuries, includes no materials that would be classed by the Department of Transportation as Class A, B, or C explosives.

Class B explosives are defined as explosives (those chemical compounds, mixtures or devices, the primary or common purpose of which is to function by explosion) which in general function by rapid combustion rather than detonation. This class includes some explosive devices such as special fireworks, flash powders, some pyrotechnic signal devices, and liquid or solid propellant explosives and smokeless powders. These materials would also be regulated by the Alcohol, Tobacco and Firearms Division of the Department of Treasury and any person dealing with them in terms of sale, transportation, use or storage would have to be specifically licensed by the Department of Treasury for that purpose. A review of DOT rules, Alcohol, Tobacco and Firearms Division rules, and the concerns of EPA does not indicate that any materials covered by the DOT Class B explosives definition would be covered by the definition of reactive waste developed by EPA.

The DOT defines Class C explosives as those manufactured articles which contain Class A or Class B explosives or both as components, but in restricted quantities. This definition also includes certain types of fireworks. The most common example of a Class C explosive would be small arms ammunition. Again, because the classification depends upon the primary purpose or function of the material being able to act as an explosive, it is unlikely that many hazardous wastes as defined by EPA would

fall under the DOT classification of Class C explosive. Federal, State and local controls on the disposition of ammunition would also serve to limit the degree of likelihood of this material being profferred to a hazardous waste disposal site.

In 49 CFR 173.150, DOT defines the classification of flammable solid as any solid material, other than one already classed as an explosive, which may pose a flammability hazard, or which is spontaneously combustible, and "water reactive materials." Section 171.8 declares that "water reactive material (solid) means any solid substance (including sludges and pastes) which, by interaction with water, is likely to become spontaneously flammable or to give off flammable or toxic gases in dangerous quantities." That portion of the EPA definition which describes wastes which may react violently with water or which generate toxic fumes when mixed with water would appear to fit within the water reactive material phase of DOT's flammable solid classification.

Flammable solids must not be packed in the same outside container with corrosive liquids unless the corrosive liquids are in bottles cushioned by incombustible absorbent material in tightly closed metal containers. All containers must be tightly and securely closed and inside containers must be cushioned as prescribed, or in any case when necessary to prevent leakage of those containers.

"Limited quantities" of flammable solids are given exceptions from DOT labeling and DOT specification packaging requirements when packed in inside containers not over one pound net

weight each, in outside containers not exceeding 25 pounds net weight each. These limited quantity shipments also are not subject to DOT placarding requirements or operational requirements imposed upon motor carriers and rail carriers other than the requirement to have shipping documents accompanying the freight. To the extent that a hazardous waste material is water reactive it would be regulated as a flammable solid and would fall within these limited quantity provisions in such small quantities.

If shipped in larger quantities, this flammable solid waste material must be packaged in accordance with 49 CFR 173.154 pertaining to the shipping name "water reactive solid, n.o.s." These packagings are as follows:

(a) Specification 6A, 6B, or 6C metal barrels or drums;

(b) Specification 17C, 17E, 17H, 37A or 37B metal drums (single trip);

(c) Specification 12B fibreboard boxes with inside containers that must be metal cans, sliding-lid wooden boxes, or fibre cans or boxes;

(d) Specification 15A or 15B lined wooden boxes;

(e) Specification 15A, 15B, 15C, 16A or 19A wooden boxes with inside containers;

(f) Specification 21C fibre drums;

(g) Specification 22A plywood drums;

(h) Specification 22B plywood drums with inside metal drums meeting Specification 2F;

(i) Specification 12B fibreboard boxes of certain construction containing tightly closed polyethylene or equally efficient plastic bags with minimum thickness of .004 inch;

(j) Specification 12A fibreboard boxes with inside glass bottles; and

(k) Specification 12B fibreboard boxes with inside polyethylene bottles not over 1 gallon capacity each.

Limited quantity shipments of flammable solid, water reactive materials are exempt from labeling and specification packaging. Shipping papers would describe the material as "water reactive solid, n.o.s." with the classification of a flammable solid. For those packagings that would require labeling there would be dual labeling with both the "flammable solid" label and the "dangerous when wet" label described in Sections 172.420 and 172.423, respectively. Unlike most other hazardous materials, at least in highway transportation, any quantity of a flammable solid bearing the "dangerous when wet" label must be placarded on each side and each end of any motor vehicle, rail car, or freight container containing that material. The unusual placard to be used in the "Flamable Solid W" placard prescribed in 49 CFR Section 172.548. The unusual "W" marking indicates not only the flammability of the product, but also the fact that it is dangerously reactive with water.

For EPA defined reactive waste materials not encompassed by the Department of Transportation's current explosive classification or the "dangerous when wet" flammable solid classification, there are no specific requirements currently prescribed by DOT with regard to packing, marking, labeling or handling in commerce.

2. Corrosive Wastes. A material would be defined by EPA as a corrosive waste if a representative sample of the waste had either of the following properties:

(a) A pH less than 2 or greater than 12 as determined by a specified procedure.

(b) A corrosion rate greater than 0.250 inches per year on steel (SAE 1020) at a test temperature of 130°F. as determined by a specified procedure.

The first criterion of the preliminary EPA definition of corrosiveness relates to the pH of material and does not relate directly by specific tests to the visible destruction or irreversible alteration of human skin tissue as the DOT definition does. In 49 CFR 173.240(a)(1) DOT declares that a material is considered to be destructive or to cause irreversible alteration in human skin tissue if, when tested on the intact skin of the albino rabbit by a prescribed technique, the structure of the tissue at the site of contact is destroyed or is changed irreversibly after an exposure period of 4 hours or less. The second criterion of the preliminary EPA corrosive definition is identical to the second criterion used by DOT.

The Department of Transportation adopted this quantified definition of corrosive material in a lengthy rule making in their Docket No. HM-57. In the early stages of that rule making, for the same reasons described by EPA, the regulators at DOT explored using the concept of pH as a defining criteria. Simply stated, the pH criterion was not adopted by DOT because of the dramatic over-inclusion of materials in the class which, in fact,

would not be destructive to tissue. It is strongly suggested, that if EPA wishes to regulate the effect of the differential between the pH of a waste and the pH of the soil, waters, disposal site, etc., the term "corrosive" not be used to define this category of regulated material. A name that would cause less confusion should be chosen.

Many materials with pHs of less than 2 and more than 12 are not, in fact, corrosive, and undue and harmful confusion would be caused by the discrepancy between this use of the term corrosive and its more common use in the DOT, OSHA, FDA, CPSC context. In its current regulatory context at other agencies, the word "corrosive" is given its dictionary meaning, such as that shown in the Random House Dictionary of the English Language (Unabridged Edition): "Having the quality of corroding, eating away, or consuming." Many of the cited incidents in the background papers for the preliminary EPA definition indicate a concern with the adverse environmental and biological reaction to differentials in pH, but these reactions are not properly characterized as an "eating away or consumption" of one material by another. Accordingly, it is again stressed that use of the word corrosive in this regulatory context would inject an element of unwarranted confusion into the Federal safety regulatory process.

Among the reasons DOT found the pH measure to be overly inclusive was the fact that, although a material might have a low pH, the amount of reaction or damage that would take place with a contacted substance would vary because the pH does not in itself reveal the quantity of harmful product involved in a

solution. For example, if a small amount of destructive acid that has a pH of 2 is involved, it will be expended readily in any reaction thereby having very little effect overall if the reactant surface is proportionately large. There is also a problem with buffered solutions because such solutions resist change in hydrogen/ion concentration and pH can be a deceiving measurement. For example, a 20% sulphuric acid solution with a pH to be regulated by EPA can completely dissolve 18/8 chromium nickel steel at 90°C., but the addition of 1% mercuric sulphate stops all attack on the metal. The addition of the mercuric sulphate, however, would not affect the pH although it totally inhibits the corrosive properties of the solution.

In the event EPA concludes that certain materials, with a differential in pH that would be environmentally harmful at the disposal site, should not be accepted at that disposal site, the agency should give serious consideration to whether there is any need to regulate such materials or their packaging in transportation to any such disposal site. The trade-off of easy measurement and determination of the applicability regulation, with resultant coverage of an unduly wide range of materials by a corrosive definition, would not seem to be economically justifiable in terms of actual corrosion and threat to persons, property and the transportation environment. In this regard it is interesting to note that Appendix A to the background papers for the preliminary EPA definition of corrosiveness includes 14 damage incidents, only three of which involve packaging. All

other incidents involved bulk quantities of materials in sludge ponds and other disposal sites or holding lagoons.

In addition to the albino rabbit test and the NACE steel corrosion test prescribed by DOT, the DOT definition declares that if human experience or other data indicate that the hazard of a material is greater or less than indicated by the results of the specified tests, DOT may revise its classification or make the material subject to the requirements of the regulations.

With regard to DOT regulation of corrosive materials it is also pertinent to note the creation of a new class of articles called "Other Regulated Materials (ORM) - Group B." In 49 CFR 173.500, ORM-B materials are defined as materials (including solids when wet with water) capable of causing significant damage to a transport vehicle or vessel from leakage during transportation. In addition to materials specified by name as ORM-B materials, this class includes any liquid substance that has a corrosion rate exceeding 0.250 inches per year on aluminum (non-clad 7075-T6) at a test temperature of 130°F. An acceptable test for DOT purposes is described in NACE Standard TM-01-69. ORM-B materials that fall within that classification by the aluminum corrosive test would bear the proper DOT shipping name of "ORM-B, n.o.s." As such, these materials would be regulated only when shipped by air. In this mode, packages would have to be marked "ORM-B, n.o.s.", and would have to meet the general packaging criteria of the regulations for all materials, such as requirements on compatibility of the packaging with its lading. For packagings of 110 gallon capacity or less, sufficient outage

must be provided so the packaging will not be liquid full at 130°F. (55°C.). When a liquid or solid ORM-B material has an absolute vapor pressure exceeding 16 psi at 100°F. (38°C.), the primary packaging must be capable of withstanding the inside vapor pressure at 130°F. without leakage. Any material classed as an ORM material which may cause a hazard in transportation due to its reaction with water must be packaged with either an inner or outer waterproof packaging. In air transportation these packagings would have to be accompanied by properly prepared DOT shipping papers describing the material and the quantity in the shipment.

Bottles containing DOT regulated corrosive liquids may not be packed in the same outside container with any other article, except in certain very narrowly prescribed instances. (DOT's Docket No. HM-121 is about to change this regulation by declaring that one may not mix corrosive liquid bottles in the same packaging with any other DOT-regulated hazardous material.) All containers of corrosive liquids must be tightly and securely closed and inside containers must be cushioned as prescribed, or in any case when necessary to prevent breakage or leakage.

Corrosive liquids in small packagings are given a limited quantity exception from DOT specification packaging and labeling (except when offered for transportation by air), and are relieved from operational requirements imposed on highway and rail carriers other than shipping papers, when packaged as follows:

(a) In bottles having a rated capacity not over 16 ounces by volume, each enclosed in a metal can packed in a strong outside packaging.

(b) In metal or plastic containers having a rated capacity not over 16 ounces by volume in strong outside packaging.

Corrosive solids are given a limited quantity exemption in the following packaging:

(a) In earthenware, glass, plastic or paper containers not exceeding 5 pounds capacity each, packed in metal, wooden or fibreboard outside packaging not exceeding 25 pounds net weight each.

(b) In metal, rigid fibre or composition cans or cartons, or rigid plastic containers of not more than 10 pounds capacity each, overpacked in metal, wooden or fibreboard outside containers not exceeding 25 pounds net weight each.

Corrosive liquid wastes that are not listed by a specific chemical name in the DOT regulations may be shipped under several generic shipping names, including "corrosive liquid, n.o.s.," "acid, sludge; sludge acid; spent sulphuric acid; or, spent mixed acid;" "alkaline corrosive liquids, n.o.s.; alkaline liquids, n.o.s.; alkaline corrosive battery fluid; boiler compound liquid solution;" "cleaning compound, liquid; coal tar dye, liquid; dye, intermediate liquid; mining reagent, liquid; and, textile treating compound mixture, liquid;" "compounds cleaning, liquid (containing no more than 60% hydrofluoric acid);" "electrolyte (acid) and alkaline corrosive battery fluid;" and, "cleaning compound, liquid containing hydrochloric (muriatic) acid."

Materials shipped under the DOT shipping name "corrosive liquid, n.o.s.", in quantities in excess of the limited quantity packaging exceptions, would have to be transported in DOT specification packaging as follows:

(a) Specification 1A, 1B, 1C or 1E glass carboys in boxes, kegs or plywood drums.

(b) Specification 1D boxed glass carboys of not over 6.5 gallons nominal capacity and equipped with vented closures.

(c) Specification 5A, 5B, 5C or 5M metal barrels or drums.

(d) Specification 15A, 15B, 15C, 16A or 19A wooden boxes with inside containers of glass, earthenware, polyethylene or other non-fragile plastic material not over one gallon each.

(e) Specification 28 metal-jacketed lead carboys.

(f) Specification 5D rubber-lined metal barrels or drums.

(g) Specification 5H lead-lined metal barrels or drums.

(h) Specification 43A rubber drums.

(i) Specification 12B fibreboard boxes with inside polyethylene containers or containers of other non-fragile plastic material resistant to the lading, having threaded closures or other equally efficient closures, not over 1-gallon capacity each, suitably cushioned to prevent movement within the box.

(j) Specification 15P or 22C glued plywood or wooden boxes or plywood drums as prescribed with Specification 2T polyethylene inside containers.

(k) Specification 17C, 17E or 17F single trip metal drums with openings not exceeding 2.3 inches in diameter.

(l) Specification 17H single trip metal drums, authorized only for viscous cleaning compounds, liquid.

(m) Specification 6D or 37M non-reusable cylindrical steel overpacks with inside Specification 2S, 2SL or 2U polyethylene packaging.

(n) Specification 17H, 37A or 37B single trip metal drums with welded side seams, not over 5-gallons capacity, lined throughout with a pliable plastic material impervious to the lading.

(o) Specification 12A fibreboard boxes with inside glass, polyethylene or other non-fragile plastic bottles not over 1-gallon capacity each.

(p) Specification 37P steel drums with polyethylene non-reusable liners.

(q) Specification 16D wire-bound wooden overwrap with inside Specification 2T, 2TL, 2S or 2SL polyethylene containers.

(r) Specification 12P fibreboard boxes with inside Specification 2U polyethylene containers not over 5-gallons capacity each.

(s) Specification 16A wire-bound wooden boxes with inside Specification 2U polyethylene containers.

(t) Specification 12B fibreboard boxes with inside polyethylene bottles not over 5-gallons capacity each, and not more than 1 bottle in each outside box.

(u) Specification 21P fibre drum overpack with inside Specification 2S, 2SL or 2U polyethylene containers.

(v) Specification 12A or 12B fibreboard boxes with inside aluminum containers not over 5-pounds capacity each (approved by the Bureau of Explosives).

(w) Specification 34 polyethylene drums not over 30-gallons capacity.

(x) Specification 33A non-reusable polystyrene case having 1 inside glass bottle not over 16-ounces capacity.

(y) Cylinders for any compressed gas, except acetylene, with valves protected.

(z) Specification MC303, 304, 307, 306, 310, 311 or 312 tank trucks.

(aa) Specification 103, 111, 104, 115 or certain AAR tank cars.

(bb) Specification 42B aluminum drums.

Shipments of corrosive wastes that would be covered by the DOT shipping names "acid, sludge; sludge acid; spent sulphuric acid; or, spent mixed acid" would have to be in DOT specification packagings as follows:

(a) Specification 1A, 1D or 1E carboys in boxes or plywood drums (for spent sulphuric only).

(b) Specification 15A, 15B, 15C, 16A or 19A wooden boxes with inside containers of glass or earthenware not over one gallon each.

(c) Specification 103 and 111 tank cars.

(d) Specification MC310, 311 or 312 tank trucks.

(e) Specification 60 portable tanks.

Waste corrosive liquids that would be covered by the shipping names "alkaline corrosive, n.o.s.; alkaline liquids, n.o.s.; alkaline corrosiv battery fluid; and, boiler compound, liquid solution" may be packed in containers authorized for the shipment of "corrosive liquids, n.o.s.," and may also be packed in the following specification containers:

(a) Specification 15A, 15B, 15C, 16A or 19A wooden boxes with glass or earthenware inside containers not over 2 gallons each, or with metal inside containers not over 5 gallons each.

(b) Specification 5 metal drums with openings not exceeding 2.3 inches.

(c) Specification 17H single trip metal drums (for liquid boiler compounds or liquid water treatment compounds only).

(d) Specification 103, 104, 105 and 111 tank cars.

(e) Specification MC310, 311 or 312 tank trucks.

(f) Specification 60 portable tanks.

(g) Specification 12B fibreboard boxes with inside glass containers not over 16-ounces capacity each.

(h) Specification 29 mailing tubes with no more than one inside polyethylene bottle not over 1-quart capacity.

(i) Specification 1H metal crates with inside polyethylene container meeting Specification 2T.

Corrosive liquid wastes that would be described by the DOT shipping names "cleaning compound, liquid; coal tar dye, liquid; dye, intermediate liquid; mining reagent, liquid; and textile treating compound, mixture, liquid" may be packaged in the same packagings as prescribed for "corrosive liquids, n.o.s.," but may also be placed in packagings similar to those mentioned for corrosive liquids, n.o.s., but not meeting the detailed specification requirements of 49 CFR Part 178. In other words, a liquid cleaning compound that is authorized in 49 CFR 173.245 for shipment in a 17H open-head drum may be shipped in a non-DOT specification open-head steel drum. This packaging relief is predicated upon the assumption that materials in the cleaning compound and textile treating compound categories are less corrosive than many of the materials that otherwise may be described by the "corrosive liquid, n.o.s." description.

Cleaning compounds containing not more than 60% hydrofluoric acid may be packed as if they were straight hydrofluoric acid, or may be packed in the following DOT specification packagings:

(a) Specification 12B fibreboard boxes with inside containers of natural rubber, ceresine, lead or other material of equal strength and not subject to destruction by the lading.

(b) Specification 22B plywood drums equipped with molded liners approved by the Bureau of Explosives.

(c) Specification 16A wire-bound wooden boxes with inside Specification 2U polyethylene containers.

(d) Specification 6D or 21P cylindrical steel overpack or fibre drum overpack with inside Specification 2U polyethylene containers not over 15-gallons capacity.

Liquid wastes that properly would be described by the DOT shipping name "electrolyte (acid) and alkaline corrosive battery fluid" would be packaged in DOT specification containers as follows:

(a) Specification 43A rubber drums.

(b) Specification MC310, 311 or 312 tank trucks, except that unlined tanks may not be used.

(c) Specification 60 portable tanks, except that unlined tanks may not be used.

(d) Specification 12B or 12C fibreboard boxes with inside containers of polyethylene or other electrolyte acid resistant non-fragile materials; unless the inside containers are rigid or semi-rigid in nature, they must be contained in other strong inside containers. (This is the so-called bag-in-a-box specification package.)

(e) Specification 15A, 15B, 15C, 16A or 19A wooden boxes with inside containers of polyethylene or other electrolyte acid resistant plastic, not over one gallon each.

(f) Specification 1EX carboys in plywood drums.

(g) Specification 12B fibreboard boxes of at least 275 pound test, double-wall corrugated fibreboard, or 325 pound test, double-faced corrugated fibreboard, with no more than 12 inside glass bottles of not over 1 quart-capacity each.

(h) Specification 12B fibreboard boxes having not more than 1 inside glass bottle not over 1-gallon capacity.

(i) Specification 12A fibreboard boxes with inside glass bottles not over 1 gallon, and no more than 4 inside containers exceeding 5 pints each packed in the same outside box.

(j) Specification 37P non-reusable steel drums with polyethylene liners.

(k) Specification 6D or 37M non-reusable cylindrical steel overpacks with inside Specification 2S polyethylene containers.

(l) Specification 12B corrugated fibreboard boxes with plastic bags described in 49 CFR 178.205-37.

Liquid waste corrosives that would be described by the DOT shipping name "cleaning compound, liquid, containing hydrochloric (muriatic) acid" and that did not meet the limited quantity exception criteria would have to be shipped in the following DOT specification packaging:

(a) Specification 15A, 15B, 15C, 16A or 19A wooden boxes with inside containers of glass, earthenware, polyethylene or other non-fragile material resistant to the lading, not over 1 gallon each.

(b) Specification 5D rubber-lined metal barrels or drums.

(c) Specification 43A rubber drums.

(d) Specification 1A, 1C or 1K carboys in boxes or kegs.

(e) Specification 1D, 1E or 1EX single trip glass carboys in boxes or plywood drums of not over 6.5 gallon nominal capacity and equipped with vented closures.

(f) Specification 103 or 111 tank cars equipped with certain specified safety relief devices.

(g) Specification MC310, 311 or 312 tank trucks lined with rubber or equally acid resistant material of equivalent strength and durability.

(h) Specification 60 rubber-lined portable tanks.

(i) Specification 1H, 15P or 22C metal crates with inside polyethylene carboys, or glued plywood or wooden boxes or plywood drums with inside Specification 2T or 2TL polyethylene containers.

(j) Specification 17H, 37A or 37B single trip metal drums not over 5-gallons capacity each, authorized only for 15% or less inhibited hydrochloric (muriatic) acid solution.

(k) Specification 12A or 12B fibreboard boxes with inside polyethylene containers or other non-fragile plastic material resistant to the lading of not more than 3-gallons capacity, suitably cushioned to prevent movement in the box.

(l) Specification 12A fibreboard boxes with inside glass bottles not over 5-pints capacity each.

(m) Specification 6D or 37M non-reusable cylindrical steel overpacks with inside Specification 2S, 2SL, 2T, 2TL or 2U polyethylene containers.

(n) Specification 37P steel drums with non-reusable polyethylene liners.

(o) Specification 16D wire bound wooden overwrap with inside Specification 2T, 2TL, 2S or 2SL polyethylene containers.

(p) Specification 12C fibreboard boxes with inside 5-gallon nominal capacity polyethylene bottles.

(q) Specification 21P fibre drum overpack with inside Specification 2T, 2S, 2SL, or 2U polyethylene containers.

(r) Specification 12P fibreboard boxes with inside Specification 2U polyethylene containers not over 5-gallons capacity each.

(s) Specification 16A wire-bound wooden boxes with inside Specification 2U polyethylene containers.

(t) Specification 22C polywood drums with inside Specification 2TL polyethylene containers not over 5-gallons nominal capacity.

(u) Specification 33A polystyrene non-reusable cases with non-reusable inside glass bottles not over 5-pints capacity each.

(v) Specification 12R paper-faced, expanded polystyrene board box with not more than four Specification 2E inside polyethylene bottles not over 1-gallon capacity each.

Cleaning compounds containing hydrochloric (muriatic) acid that do not contain over 28% such acid, in addition to the preceding list of containers, may be shipped in the following DOT specification packaging:

(a) Specification 12B fibreboard boxes constructed of at least 275-pound test double-wall corrugated fibreboard, or 325-pound test double-faced corrugated fibreboard, with no more than 12 inside glass bottles of not over 1-quart capacity each.

(b) Specification 12A fibreboard boxes with inside glass bottles not over 1-gallon capacity each, and no more than 4 inside bottles exceeding 5-pints capacity each in the same outside container.

Wastes meeting the DOT corrosive solid definition may be shipped under the chemical name of the material if listed by DOT in 49 CFR 172.101, or under the name "corrosive solid, n.o.s." Corrosive solids, n.o.s., that do not meet the limited quantity exception may be shipped in the following non-specification packagings that meet the general quality requirements for all hazardous materials containers:

(a) Metal, wooden or fibreboard boxes with inside earthenware, glass, metal, plastic, or fibre or composition board containers of no more than 10 pounds net weight capacity each.

(b) Fibreboard boxes with inside paper bags not over 50 pounds total net capacity.

(c) Fibreboard boxes with one inside plastic bag not over 120 pounds net weight capacity.

(d) Metal drums.

(e) Fibre drums not exceeding 550 pounds net weight and not over 55-gallons capacity.

(f) Plastic drums or pails not exceeding 80 pounds net weight and not over 6-gallons capacity.

(g) In bags that will withstand 4 drops from a height of 4 feet, with the authorized net weight of the bags not to exceed 110 pounds.

(h) Metal portable tanks or closed bins of not over 660-gallons capacity and 7,000 pounds gross weight.

(i) Fibreglass or rubber tanks or closed bins of not over 74 cubic feet capacity.

(j) Sift-proof metal cargo tanks or tank cars or hopper type or pneumatic bulk vehicles.

In addition to the packaging requirements for DOT regulated corrosive liquids and solids, it is important also to note the general prohibitions against co-loading corrosive liquids in the same package (Section 173.242) with other materials, or in the same overpack (Section 173.25) with other hazardous materials, except under very carefully prescribed packaging conditions.

In conclusion, a wide range of DOT specification packaging is authorized for the shipment of corrosive liquids and an even wider range of non-specification packaging is authorized for the shipment of DOT regulated corrosive solids. By the pH criterion of EPA's preliminary definition of corrosiveness, however, a far greater population of materials will be regulated under the Resource Conservation and Recovery Act, and one must presume that a much wider range of non-specification packaging is in use today for such materials.

3. Flammable Wastes. The preliminary draft EPA definition of flammable waste reads as follows:

> "A waste is a flammable waste if a representative sample of that waste has either of the following properties:
>
> (1) Any liquid waste which has a flash point greater than 140°F. as determined by a Tagliabue Closed Cup Tester.
>
> (2) Any non-fluid waste which may cause fire through friction or which may be ignited readily and when ignited burns so vigorously and persistently as to create a hazard to persons and the environment."

The first portion of EPA's preliminary definition of flammable waste is keyed to the flash point of liquid wastes as determined by the closed-cup tester. This mechanism for measuring flammability is comparable to that used by the U.S. Department of Transportation and OSHA. The Food and Drug Administration and Consumer Product Safety Commission are still linked to an open cup tester and their definition is comparable to what was the DOT definition before 1972, but legislation now before Congress would adjust this restriction found in the Hazardous Substances Labeling Act. The DOT regulations do not define "liquid," but it is generally understood that if a material at a temperature of 100°F. will pour readily from its container it is considered a liquid. The concern here is the flow of materials that might result from a punctured container in transportation and the spreading of fire or the potential for fire from the immediate site of the puncture or other parts of the transportation vehicle.

There are several substantive differences between the DOT definition of the flammable liquid class and that proposed to be adopted by EPA. While the EPA definition would extend to 140°F., the DOT definition of flammable liquid has a flash point cut-off at 100°F., as determined by the closed-cup tester. In addition to this flat cut-off point in the definition, there are several exceptions and variations on the definition, to accommodate specific circumstances where the test method is inaccurate, or where the known properties of materials are different from those indicated through the various

test methods. Thus, for example, in 49 CFR 173.115(b) DOT indicates that "an aqueous solution containing 24% or less alcohol by volume is considered to have a flash point no less than 100°F. (37.8°C.) if the remainder of the solution does not meet the definition of a hazardous material." This particular exception was adopted to recognize the fact that alcohol/water mixtures tend to give lower flash point readings in the closed-cup tester than accurately reflect the fire characteristics of these materials. In addition, in the DOT flammable liquid classification there is a distinction drawn between materials with a flash point below 73°F. and materials with a flash point of 73° to 100°F. The lack of such specific exceptions to the definition in the EPA document will impact the packaging for some of the flammable liquid wastes that will be regulated by EPA.

As noted above with regard to the term "corrosive," indiscriminate use of the term "flammable" in the transportation context, meaning a liquid other than one so termed by the existing transportation system, will inject what the contractor believes to be a totally unwarranted element of confusion into the transportation community. It is recommended that if the preliminary flash point cut-off of 140°F. is retained by EPA (and there is nothing in the underlying literature to indicate the advisability of its retention for transportation purposes), that the term "flammable" not be used. If controls were deemed necessary at the disposal site based on the flash point of the material, a statement on the manifest indicating the

approximate flash point of the waste would be sufficient without having to call the material a flammable, thereby confusing the existing transportation safety system.

The preliminary EPA definition of a non-fluid flammable waste is similar to DOT's definition of a flammable solid. Certain materials would be included in the DOT definition, however, that would not be included in the EPA classification. For example, DOT regulates the transportation of materials that are hot with retained heat from manufacturing or processing but EPA would not cover such materials, presumably on the theory that in disposal sites that retained heat from manufacturing or processing would be dissipated. One might question whether this rationale should be controlling, since the focus of other definitions and other requirements seems to be on the transportation segment of disposal and the immediate receipt of materials at the disposal site, as well as the longer term storage. Other materials not considered for inclusion in the EPA non-fluid waste definition are materials that are spontaneously combustible. Materials that are water reactive, which DOT would class as flammable solids, probably would fit within the reactive classification proposed by EPA.

DOT defines a "combustible liquid" as that liquid that does not meet the definition of any other hazard class and that has a flash point at or above 100°F. and below 200°F. With this definition there also are specific exceptions and variations having to do with the inaccuracies of test methods or properties of specific materials when tested by these methods.

Liquids that will ignite spontaneously in dry or moist air, or below 130°F. (54.5°C.), are called pyroforic liquids and are classed as flammable liquids, subjected to the regulatory requirements for flammable liquids.

Combustible liquids, in other words, those with flash points ranging from 100° to 200°F., are not subject to any DOT specification packaging requirements. There is no regulation whatsoever of these liquids in packagings of less than 100 gallons each, and for unit quantities in excess of 110 gallons, the requirements focus on communication of the presence of the material as opposed to requirements upon containment of that material. Thus, regulation of combustible liquids by DOT only applies to bulk transportation and only pertains to placarding and shipping papers for those liquids.

As with every classification of hazardous material regulated by DOT, there is certain regulatory relief granted to limited quantities of flammable liquids. Among the relief granted is that from the use of DOT specification packaging when flammable liquids of flash points up to 100°F. are (a) in metal containers not over 1-quart capacity each, packed in strong outside containers, (b) in containers having a capacity not over 1 pint or 16 ounces by weight each, packed in strong outside containers, or (c), for flammable liquids with flash points of 73° to 100°F., in inside containers having a rated capacity of 1 gallon or less when packed in strong containers. (For these higher flash point materials given relief on packaging, the flash point of the material must be marked on the

outside of the packaging.) Liquids in these limited quantities are relieved from requirements for DOT specification packaging and from labeling requirements (except when offered for transportation by air), but they must be accompanied by shipping papers. They do not have to meet the placarding or other operational requirements imposed on motor carriers and rail carriers.

DOT continues its recognition of the lower hazard of materials with flash points from 73° to 100°F. in granting relief from specification packaging only for liquids in that flash point range when in units of 110 gallons or less. (Again the greater relief offered here is predicated upon a marking of the flash point on the outside of the packaging.) This relief from use of more expensive specification packaging is not accompanied by relief from labeling requirements, and material in this category in these larger quantities does not fit DOT's definition of the term "limited quantity."

Other than waste straight chemicals, which would be shipped under their prescribed chemical shipping name, mixed flammable liquid wastes would be shipped under the proper DOT shipping name of "flammable liquid, n.o.s." If the material were not in small packages that would fit the limited quantity exceptions, it would be shipped in DOT specification packaging prescribed in 49 CFR 173.119. Each package would have to be marked with the name of contents, i.e., "flammable liquid, n.o.s.," and would have to bear the red, diamond-shaped, flammable liquid label showing the international flame symbol and the signal words "Flammable Liquid."

Section 173.119 prescribes packaging based upon the characteristics of the material including flash point, vapor pressure, viscosity, and potential secondary properties of the material. For flammable liquids having flash points of 20°F. or below, the following specification packagings are prescribed:

(a) Specification 1A, 1C, 1D glass carboys, boxed or in barrels or kegs with a capacity not over 5 gallons.

(b) Specification 5, 5A, 5B, 5C or 5M metal barrels or drums with openings not exceeding 2.3 inches.

(c) Specification 17E metal drums with openings not exceeding 2.3 inches (gauge of metal is prescribed).

(d) Specification 17C metal drums with openings not exceeding 2.3 inches.

(e) Specification 12B fibreboard boxes with inside glass or earthenware containers not over 1 quart each, or metal cans not over 1 gallon each.

(f) Specification 15A, 15B, 15C, 16A, 19A or 19B wooden boxes with inside containers which must be metal pails, kits or cans not over 10 gallons each, or inside glass or earthenware containers not over 1 gallon each.

(g) Specification 21C, 22A or 22B fibre drums and plywood drums with a single inside glass, earthenware or metal container not over 1 gallon capacity in each drum (the inside container must be cushioned to prevent breakage or leakage).

(h) Specification 42B, 42C or 42H aluminum barrels or drums.

(i) Cylinders as prescribed for any compressed gas except acetylene.

(j) Specification 103, 104, 105, 106, 109, 110, 111, 112, 114, 115 and certain ARA tank cars.

(k) Specification MC-300, 301, 302, 303, 304, 305, 306, 330 or 331 tank trucks.

(l) Specification 12D fibreboard boxes with inside glass or earthenware containers not over 1 gallon each.

(m) Specification 17H or 37A metal drums with inside glass packagings not over 9 pints capacity each.

(n) Specification 12A fibreboard boxes with inside glass bottles not over 1 gallon capacity each.

(o) Specification 6D cylindrical steel overpack with an inside Specification 2S polyethylene container.

(p) Specification 51 or 57 portable tanks.

Flammable liquids with flash points above 20°F. to 73°F., that do not meet limited quantity exceptions, must be packaged in the following DOT specification packaging:

(a) Containers that would be prescribed for flammable liquids with flash points below 20°F. except that openings greater than 2.3 inches in diameter in barrels and drums are authorized when permitted by the packaging specification itself.

(b) Specification 17E or 17H single trip metal drums.

(c) Specification 10B wooden barrels or kegs for alcohol and alcohol/water mixtures.

(d) Specification 12B fibreboard boxes with inside containers of glass, earthenware, polyethylene or metal not over 1 gallon each.

(e) Specification 12E fibreboard boxes with one or two rectangular metal inside containers not over 5 gallons each.

(f) Specification 6K metal barrels or drums of Type 304 stainless steel.

(g) Specification 37P steel drums with polyethylene liners.

(h) Specification 6D or 37M non-reusable cylindrical steel overpack with an inside Specification 2S or 2SL polyethylene container.

(i) Specification 21P fibredrum overpack with inside Specification 2S or 2SL polyethylene container.

(j) Specification 37D non-reusable steel drums for any commodity not exceeding 10 pounds per gallon.

The vapor pressure of the flammable liquid at certain specified temperatures is essential to the determination of authorized packaging for the flammable liquid. When the vapor pressure of the liquid does not exceed 16 pounds per square inch absolute (p.s.i.a.) at 100°F., the flammable liquids may be packed as prescribed above. When the vapor pressure exceeds 16 p.s.i.a. at 100°F. but does not exceed 27 p.s.i.a., the liquids must be packed in the following DOT specification containers:

(a) Specification packagings authorized for liquids for flash points below 20°F. described in the paragraphs above and listed above as items (a) through (i) (except Specification 17E drums).

(b) Specification 103, 104, 105, 106, 109, 110, 111, 112, 114, 115, and certain ARA tank cars.

(c) Specification MC-304, 307, 330 or 331 tank trucks.

(d) Specification 51 portable tanks.

When the vapor pressure of the liquid waste exceeds 27 p.s.i.a. at 100°F. but does not exceed 40 p.s.i.a., the liquids must be packed in the following DOT specification containers:

(a) Specification 5A or 5P metal barrels or drums with openings not exceeding 2.3 inches.

(b) Cylinders prescribed for any compressed gas except acetylene.

(c) Specification 105, 106, 109, 110, 111, 112, 114 and certain ARA tank cars.

(d) Specification MC-304, 307, 330 or 331 tank trucks.

(e) Specification 51 portable tanks.

As defined in 49 CFR Section 173.115(b), viscous flammable liquids having a vapor pressure not exceeding 16 p.s.i.a. at 100°F., are given certain packaging specifications. The following DOT specification containers must be used:

(a) Those containers prescribed for liquids having flash points both below and above 20°F. noted above, irrespective of their flash point.

(b) Specification 6A, 6B or 6C metal barrels or drums.

(c) Specification 37A or 37B single trip metal drums not over 5 gallons each.

(d) Specification 42F aluminum barrels or drums.

Viscous flammable liquids with flash points above 20° to 73°F., and having a vapor pressure not exceeding 18 p.s.i.a. at 100°F., must be packaged in the following DOT specification containers:

(a) Specification 17E or 17H single trip metal drums.

(b) Certain packagings already authorized for other flammable liquids.

Flammable liquids that are also organic peroxides, oxidizers, corrosive liquids or poison B liquids must be packaged as follows:

(a) Specification 1A, 1D, or 1EX single trip glass carboys boxed or in plywood drums.

(b) Specification 15A, 15B, 15C, 16A or 19A wooden boxes with inside containers of glass or earthenware not over 1 gallon each, combined with incombustible packing material to absorb the contents of the inner container in the event of breakage.

(c) Specification 12B fibreboard boxes with inside glass or earthenware containers not over 1 quart each and cushioned with incombustible packing material.

(d) Specification 5, 5A, 5B, 5C, 5P and 17C or 17E single-trip metal barrels or drums.

(e) Specification 37P steel drums not over 15 gallons capacity with non-reusable polyethylene liners.

(f) Specification 12B fibreboard boxes with Specification 2E inside polyethylene bottles not over 1 gallon each.

(g) Specification 12B fibreboard boxes with 1 inside polyethylene bottle not over 5 gallons capacity.

(h) Specification 12P fibreboard boxes with inside specification polyethylene containers not over 5 gallons each.

(i) Cylinders prescribed for any compressed gas except acetalene.

(j) Specification MC-304, 307, 310, 311 or 312 tank trucks.

(k) Specification 103, 111, 112 and 115 tank cars.

(l) Specification 6D or 37M non-reusable cylindrical steel overpacks with an inside Specification 2S or 2SL polyethylene container, or with an inside Specification 2U polyethelene container not over 5 gallons capacity.

Any wastes that meet the pyroforic liquid definition in the flammable liquid class must be packed in DOT specification

containers or in devices or apparatus approved by the Bureau of Explosives of the Association of American Railroads, as follows:

(a) Cylinders prescribed for any compressed gas except acetalene and having a minimum design pressure of 170 pounds per square inch; cylinders must have certain valve protection or must be packed in strong wooden boxes and secured to protect the valves.

(b) Specification 15A, 15B or 15C wooden boxes or Specification 12B fibreboard boxes, with not more than four Specification 2A metal cans holding inside glass or metal containers not over 1 quart capacity each, having positive screw cap closures adequately gasketed; inside containers must be cushioned on all sides with dry absorbent incombustible material in a quantity sufficient to absorb the entire contents.

(c) Specification 17C or 37A single trip metal drums with inside metal cans not over 1 gallon each; inside containers shall have no opening exceeding 1 inch diameter and must be surrounded on all sides with incombustible cushioning material.

(d) Specification 105 tank cars.

(e) Specification 51 portable tanks with a minimum design pressure of 175 pounds per square inch.

(f) Specification MC-330 or 331 tank trucks having a minimum design pressure of 175 psi.

No material classed by DOT as a flammable solid may be packed in the same outside container with corrosive liquids unless those corrosive liquids are in bottles cushioned by incombustible absorbent material and are packed in tightly closed metal containers.

The limited quantity exceptions for the flammable solid classification are prescribed in 49 CFR 173.153. Relief from specification packaging and labeling is offered as well as relief from placarding and operational requirements in rail and highway transportation, but for the preparation and carriage of shipping documents describing the freight. This relief is available for flammable solids in inside containers not over 1 pound net weight each, in outside containers not exceeding 25 pounds net weight each.

Unless appearing specifically by chemical name in the DOT Hazardous Materials list in 49 CFR 172.101, flammable solid wastes would be shipped under the DOT shipping name "flammable solid, n.o.s." Those packagings which did not qualify for limited quantity exceptions must be packaged as prescribed in Section 173.154. Like all other hazardous materials, flammable solids must be packed in specification containers of a design and constru tion of materials that will not react dangerously with or be decomposed by the chemical packed in them. The prescribed packaging for flammable solids, n.o.s., is listed earlier in this report for water reactive materials classed as flammable solids that probably would fall within the preliminary EPA definition of reactive materials.

In conclusion, waste defined by EPA as a flammable liquid or a flammable non-fluid hazard will be in DOT specification packaging unless one of the following conditions occurs:

(a) The material fits the limited quantity paragraphs prescribed by DOT for both flammable liquids and flammable solids.

(b) The material has a closed-cup flash point of 73° to 100°F. and is in units not exceeding 110 gallons capacity each.

(c) The liquid has a flash point of 100° to 140°F.

(d) The liquid is given a specific exception from DOT regulation, such as that provided to alcoholic beverages, when no such exception exists in the EPA definition.

4. Infectious Wastes. As is accurately noted in the background papers for the preliminary EPA definition of infectious waste, the Department of Transportation has only limited coverage of such materials. The extent of DOT coverage, based on a 1960 amendment to the enabling statute, is to authorize regulation of "etiologic agents." History does not contain any indication that DOT, or its predecessor agency the Interstate Commerce Commission, sought the authority to regulate these materials and there has been a noticeable reluctance at DOT to enter the arena of biologic or infectious material regulation.

Such regulations as DOT has are published in 49 CFR Sections 173.386 through 173.388. The DOT regulations involve substantial cross-reference to regulations of the Department of Health, Education, and Welfare in 42 CFR 72.25. For DOT purposes, an etiologic agent is a viable microorganism or its toxin which causes or may cause human disease and is limited to agents listed by HEW in its regulations. The background papers for the EPA preliminary definition include a lengthy list of these HEW agents, at pages 14 through 18 of the draft papers.

For volumes of etiologic agents less than 50 milliliters (ml), HEW requires the material to be placed in a securely closed, water tight container which shall be enclosed in a second durable water tight container. Several primary containers may be enclosed in a single secondary container if the total volume of all primary containers does not exceed 50 ml. The space at the top, bottom and sides between the primary and secondary containers shall contain sufficient non-particulate absorbent material to absorb the entire contents of the primary containers in case of breakage or leakage. Each set of primary and secondary containers must then be enclosed in an outer shipping container constructed of corrugated fibreboard, cardboard, wood or other material of equivalent strength.

The Department of Transportation, in Section 173.386(d), specifically excludes the following materials from any DOT regulation unless those materials happen to be otherwise regulated as flammable, corrosive, etc.:

(a) Diagnostic specimens.

(b) Biological products.

(c) Cultures of etiologic agents of 50 ml. (1.666 fluid ounces) or less in one outside package.

Under HEW regulation volumes of 50 ml. of etiologic agents or more must be packaged in units that include a shock absorbent material. This shock absorbent material must be at least equal in volume to that of the absorbent material between the primary and secondary containers at the top, bottom, and sides,

between the secondary container and the outer shipping container. Single primary containers must not contain more than 500 ml. of material. Two or more primary containers whose combined volumes do not exceed 500 ml., however, may be placed in a single secondary container. No more than 8 secondary shipping containers may be enclosed in a single outer shipping container. The maximum amount of etiologic agent which may be enclosed within a single outer shipping container must not exceed 4,000 ml.

In addition to the minimum packaging requirements prescribed by HEW. DOT declares that no one may ship any package containing over 4 litres gross volume of an etiologic agent. DOT further says that, in addition to the HEW requirements, any package containing an etiologic agent must be designed and constructed so that, if it were subject to prescribed environment and test conditions, there would be no release of the contents to the environment and the effectiveness of the packaging as a container would not be significantly reduced. The environmental and test conditions prescribed are the following:

(a) Direct sunlight in an ambient temperature of 130°F. in still air.

(b) An ambient temperature of -40°F. in still air and shade.

(c) Ambient atmospheric pressure of 0.50 atmosphere (7.3 p.s.i.a.).

(d) Vibration normally incident in the mode of transportation in which the package will be shipped.

(e) A water spray heavy enough to keep the entire exposed surface of the package (except the bottom) continuously wet during a period of 30 minutes.

(f) A free drop through a distance of 30 feet onto a flat, essentially unyielding horizontal target surface striking the surface in a position for which maximum damage is expected.

(g) Impact of the hemispheric end of a steel cylinder 1.25 inches in diameter and weighing 15 pounds, dropped from a height of 40 inches onto the exposed surface of the package expected to be the most vulnerable to puncture. The long axis of the cylinder must be perpendicular to the impacted surface.

(h) As an alternative to the preceding penetration test, a free drop of the package through a distance of 40 inches, striking the top end of a vertical cylindrical mild steel solid bar on an essentially unyielding surface in a position for which maximum damage is expected. The bar must be 1.5 inches in diameter. The top of the bar must be horizontal with its edge rounded to a radius not exceeding 1/4 inch. The bar must be at least 8 inches long and must be of such length as to cause maximum damage to the package. The long axis of the bar must be vertical to the unyielding horizontal impact surface of the package being dropped.

(i) Except for packages made of metal, wood, ceramic, plastic, or combinations of these materials, at least one sample of each type of package of a maximum size and gross weight must be filled with water and subjected to the water spray test described above. This sample package after the water spray test must then be given the free drop test and one of the penetration tests. If the outer layer of the packaging is metal, wood, ceramic, plastic, or a combination of these

materials, it is exempt from the water spray test, but it must be filled with water and subjected to consecutive free drop and penetration tests as described above.

All DOT-regulated etiologic agents and HEW-regulated etiologic agent/biomedical materials must be labeled with the rectangular HEW label, indicating the nature of the material and the international symbol for such agents.

The Department of Transportation has issued an advance notice of proposed rule making in their Docket No. HM-142, with a comment period that closed on January 21, 1977 (41FR 52086, Nov. 26, 1976). This advance notice is exploring the limitation currently appearing in the DOT regulations insofar as coverage of etiologic agents is concerned. The advance notice asked for specific comment on the following questions:

(a) Is the definition of etiologic agent given in 49 CFR 173.386 adequate?

(b) Should the definition be expanded to include agents which are harmful to plants and animals?

(c) Should the definition be expanded to include biological materials (such as recombinant DNA) used in or derived from genetic studies?

(d) Should etiologic agents in quantities of 50 milliliters or less (per outside packaging) be further regulated by the MTB as to packaging, marking, and labeling?

(e) Should the MTB, when determining the quantity of etiologic agent below which regulation is unnecessary, use a system which takes into account the potency,

i.e., the toxigenicity or virility of the agent (similar to the system used for poisons)?

(f) Should the MTB establish more specific regulatory requirements for diagnostic specimens and what should these be?

(g) Should a small size label, consistent with the general label format for other hazardous materials, be adopted to accommodate use of small packages for etiologic agents?

(h) Alternately, should a minimum package or overpack size be established to enhance safety by making it less likely for the package to become lost during shipment?

(i) To what extent do prevailing practices regarding transportation of imported shipments of etiologic agents or suspected etiologic agents, particularly diagnostic specimens, pose a health or safety risk?

(j) What kind of monitoring or clearance procedures, if any, are necessary to adequately control perceived risks attributable to transportation of imported shipments of etiologic agents?

In conclusion, the Department of Transportation, in conjunction with the Department of Health, Education, and Welfare, does regulate certain materials that would be covered by the EPA preliminary definition of infectious waste. There is no DOT specification packaging prescribed, but the packagings do have to meet certain basic HEW requirements and certain performance criteria prescribed by DOT in 49 CFR 173.387. It is most likely, however, that the majority of material that would be covered by the EPA preliminary definition of infectious waste is not covered by the current DOT regulations applicable to etiologic agents.

5. Toxic Wastes. The preliminary EPA definition of toxic materials was provided late in this study period. Absent specific definitions of that, it was assumed that the scope of the eventual EPA definition would be at least as broad as the definitions DOT has adopted for their Poison A and Poison B classifications. The preliminary definition that has been provided supports this assumption.

For DOT purposes, materials in the Poison A classification are poisonous gases or liquids of such nature that a very small amount of the gas or vapor of the liquid mixed with air is dangerous to life. This class includes the following materials.:

(a) Bromacetone.

(b) Cyanogen.

(c) Cyanogen chloride containing less than 0.9 percent water.

(d) Diphosgene.

(e) Ethyldichlorarsine.

(f) Hydrocyanic acid.

(g) Methyldichlorarsine.

(h) Nitrogen peroxide (tetroxide).

(i) Phosgene (diphosgene).

(j) Nitrogen tetroxide-nitric oxide mixtures containing up to 33.2 percent weight nitric oxide.

Class B poisons are those substances, liquid or solid, other than Class A poisons, that are known to be so toxic to man as to afford a hazard to health during transportation or

that, in the absence of adequate data on human toxicity, are presumed to be toxic to man because they fall within any one of the following categories when tested on laboratory animals:

(a) Oral toxicity. Those liquids and solids (including pastes and semisolids) which produce death within 48 hours in half or more of a group of 10 or more white laboratory rats weighing 200 to 300 grams at a single dose of 50 milligrams or less per kilogram of body weight, when administered orally.

(b) Toxicity on inhalation. Those liquids and solids (including pastes and semisolids) which produce death within 48 hours in half or more of a group of 10 or more white laboratory rats weighing 200 to 300 grams, when inhaled continuously for a period of one hour or less at a concentration of 2 milligrams or less per liter of vapor, mist, or dust, provided such concentration is likely to be encountered by man when the chemical product is used in any reasonable foreseeable manner.

(c) Toxicity by skin absorption. Those liquids and solids (including pastes and semisolids) which produce death within 48 hours in half or more of a group of 10 or more rabbits tested at a dosage of 200 milligrams or less per kilogram body weight, when administered by continuous contact with the bare skin for 24 hours or less.

(d) Human experience. The foregoing categories shall not apply if the physical characteristics or the probable hazards to humans as shown by experience indicate that the substances will not cause serious sickness or death.

There is no limited quantity packaging relief given in the DOT regulations for materials classed as Poison A.

Cylinders for Poison A materials must be maintained, in terms of periodic tests and inspection requirements, in accordance with 49 CFR 173.34. Valves must be capable of withstanding the test pressure of the cylinder and must have taper-threaded connections directly to the cylinders. The outlet caps and plugs, luting, and gaskets must be compatible with each other, the valve assembly, and the lading. The pressure of any poison gas at 130°F. must not exceed the service pressure of the cylinder, and no containers may be liquid full at 130°F. Cylinders of Poison A materials must be packed in boxes or otherwise must have adequate protection for valves. Valve protection afforded by a box must be of sufficient strength to protect all parts of the cylinders and valves from deformation or breakage resulting from a drop of at least 6 feet onto a concrete floor, impacting at the weakest point. Any cylinder not overpacked in a box must be equipped with a protective cap or other valve protect on capable of preventing damage to or distortion of the valve if it were allowed to fall from an upright position, with the side of the cap or other valve protection striking a solid steel object projecting no more than 6 inches above the floor level. All containers for Class A poisons must be tightly and securely closed and inside containers must be cushioned. No Class A poisons may be carried or loaded in any bulk highway cargo tank.

Class A poisons other than those listed specifically by chemical name in the DOT regulations would be shipped as

"Poison A, n.o.s.," and would have to be packaged for shipment in the following specification packaging:

(a) Specification 33 or 3D metal cylinders of not over 125 pounds water capacity (nominal. [1/]

(b) Specification 3A1800, 3AA1800 or 3E1800 cylinders. (Specification 3E1800 cylinders must be packed in strong wooden or metal boxes and 3A and 3AA cylinders must have valve protection or be packed in wooden or metal boxes.)

Materials classed as Poison B are granted a limited quantity exception from specification packaging but not from poison labeling. Limited quantities of Poison B liquids which are permitted the limited quantity exception (noted by a reference in 49 CFR 172.101) are granted relief from specification packaging and from operational requirements in highway and rail carriage other than shipping papers, when in tightly closed inside containers securely cushioned when necessary to prevent breakage, and meeting the following criteria:

(a) In glass packagings not over 1-quart capacity each or in metal containers or polyethylene bottles not over 1-gallon capacity each, packed in strong outside wooden boxes or barrels.

(b) In glass packagings not over 1-pint capacity each, or in metal or polyethylene packagings (other than bags) not over 1-quart capacity each, packed in strong outside fibreboard boxes.

[1/] Use of existing Specification 33 cylinders authorized, but new construction not authorized.

A material that is not listed specifically by chemical name in the DOT regulations and that meets the Poison B definition would be shipped as a "Poison B, n.o.s.," and would have to be shipped in specification packaging as follows:

(a) Specification 5, 5A, 5B or 5C metal barrels or drums with openings not exceeding 2.3 inches in diameter.

(b) Specification 17C or 17E single trip metal drums with openings not exceeding 2.3 inches in diameter.

(c) Specification 37B single trip metal drums with welded side seams, openings not over 2.3 inches in diameter, and a capacity not over 10 gallons.

(d) Specification 37A or 37B single trip metal drums with welded side seams, not over 5 gallons (authorized for pastes only).

(e) Specification 12B fibreboard boxes with glass or earthenware inside containers not over 1-quart capacity each, or with metal inside containers not over 1-gallon capacity each.

(f) Specification 15A, 15B, 15C, 16A or 19A wooden boxes with glass or earthenware inside containers not over 1-gallon capacity each, or with metal inside containers not over 10-gallons capacity each.

(g) Specification 103, 104, 105, 111, 115 and certain ARA specification tank cars.

(h) Cylinders for any compressed gas except acetylene.

(i) Specification MC-300, 301, 302, 303, 304, 305, 306, 307, 310, 311, 312 tank trucks.

(j) Specification 1A, 1D or 1E glass carboys in wooden boxes or plywood drums.

(k) Specification 12B fibreboard boxes with no more than one inside glass container of not over 1-gallon

capacity, securely cushioned. This completed packaging with glass container filled with water must be capable of withstanding six 4-foot drops onto solid concrete on the bottom, four sides and top without breakage.

(l) Specification 21C fibre drums with inside glass containers not over 1-gallon capacity each.

(m) Specification 42B, 42C or 42D aluminum drums, or Specification 42E single trip aluminum drums.

(n) Specification 15P or 22C glued plywood or wooden box, or plywood drum with inside Specification 2T polyethylene container.

(o) Specification 37P steel drums not over 5-gallons capacity with non-reusable inside polyethylene liner.

(p) Specification 6D cylindrical steel overpack with inside Specification 2S polyethylene container.

(q) Specification 12A fibreboard boxes with no more than one inside glass bottle not over 1-gallon capacity.

(r) Specification 29 mailing tubes with polyethylene bottles not over 2 quarts capacity each.

(s) Specification 42G aluminum drums.

(t) Specification 12P fibreboard boxes with inside specification 2U polyethylene containers not over 5-gallons capacity each.

(u) Specification 16A wire bound wooden boxes with inside Specification 2U polyethylene containers.

(v) Specification 12A or 12B fibreboard boxes with inside polyethylene bottles having a minimum wall thickness of 0.015 inches and provided with screw cap closures, not over 1-gallon capacity each.

(w) Specification 51 portable tanks.

The preliminary EPA definition of toxic materials includes materials that are toxic to the environment, and the materials to be regulated under such a definition will exceed the range of materials currently regulated by DOT. To the extent that DOT does not regulate such materials, DOT packaging would not be required. It is presumed that a range of non-specification packaging is used for the transportation of these materials today.

6. Survivability of DOT Packaging. EPA has expressed a concern that in addition to being able to survive the period and conditions incident to normal transportation, waste containers should be capable of surviving long periods of storage at a zero discharge level of the contained waste. Further, disposal containers will be expected to survive prolonged periods under a variety of conditions, though it is important to note that some level of discharge after burial is expected. In context with this study, as noted in the introductory chapter, no containment required past disposal was assumed to be required.

The contractor has reviewed a number of technical reports and has consistently found that, although some reports purport to deal with long-term survival of the packaging, such is not really the case. These studies, abstracts from a cross section of which are included in Appendix A, more often address the test procedures for the short-term durability of the packaging rather than the survivability over long periods of time under varying environmental conditions. This is not altogether

surprising since DOT, and its predecessor agency the I.C.C., have focused attention on the containers' suitability for transportation rather than on questions of long term containment of hazardous substances. Since transportation even under the most adverse circumstances, using the slowest mode of transport, does not take extensive time, it stands to reason that the long term containment problem has not been investigated in any depth in the context of hazardous materials transportation, storage, and disposal.

A notable exclusion pertains to bulk specification containers, such as tank cars and tank trucks. This exclusion comes about by virtue of the fact that these types of "containers" are used for extended periods of time in order to permit economic amortization of the inherent capital investments. With respect to railroad tank cars, some useful insights are gained from the Association of American Railroads (AAR) Interchange Rules as published by the AAR's Mechanical Division. Rule 88 of the Interchange Rules specifies required tank and safety valve testing, while Rule 90 specifies that no tank car older than 40 years may be interchanged in railroad service after January 1, 1981. Specific inquiry with AAR's Mechanical Division has indicated that the limit was specified on the basis of tests and experience which had shown these cars' long-term safe usefulness not to extend beyond a 40-year time period.

While no similar rules exist for tank trucks, the contractor's inquiries with manufacturers of tanks and tank linings have indicated that these are designed to meet at least

the estimated useful life of the truck itself, and which is generally in the seven to ten year range. This information, however, is not readily generalized due to the great differences in tank construction and internal as well as external liners designed to meet the specific uses of the various types of tank trucks.

One potential source of information pertaining to the long term survivability of specification packaging is the U.S. Department of the Army. The Army periodically inspects the packaging of materials stored at a number of its depots, though the results of the inspections have never been compiled and specific information is not available in a machine-readable form or even in a single location. It appears that container failures are dealt with on a "local" level at each depot and that there have been no attempts to critically and systematically analyze causes of failures and, in particular, to determine whether the suitability of the specification is borne out over time.

Still another source of some information is the compilation of Hazardous Materials Incident Reports which must be submitted by the carrier to the Office of Hazardous Materials Operations (O.H.M.O.) of DOT in the event of any unintended release of hazardous material from its packaging. (See 49 CFR 171.15 and 171.16.) In these reports, the carrier is required to indicate the contents of the container, the type of container, and the cause of the failure, but has not been required to indicate the age of the container. An analysis of the reports indicates

that almost all of the failures resulted from factors unrelated to the contents of the containers, such as loose closures, external punctures, improper handling, or manufacturing defects.

It may be concluded from the extensive inquiries on the part of the contractor, as well as from the little useful empirical shelf-life information now available, that overall specification packaging has withstood the "tests of time." It is evident, though, that in order to develop an adequate information base, long-term technical studies would have to be udnertaken that would incorporate tests designed to simulate the unique conditions likely to be encountered in waste storage and disposal sites.

7. Price and Energy Considerations for DOT Specification Packaging. DOT specification packagings, because of special testing designed to insure safe transportation of hazardous materials under a variety of conditions, as well as other factors, are generally higher in price than similar non-specification packaging. Similarly, the material and energy resources required to produce specification packaging are generally greater than for the non-specification packaging. Higher costs and consumption of greater resources are unavoidable for the most part, if the public is to be properly protected. Consistent with (a) the objective of RCRA, (b) the transportation characteristics applying to the movement of packaged hazardous wastes, as discussed in Section 2 of this chapter, and (c) the realistic need to rely on voluntary compliance by the regulated

parties, it is essential to highlight the opportunities to minimize these undesirable characteristics of specification packaging.

Placing an undue financial burden on the waste generator by requiring a more expensive packaging where a less expensive packaging would serve equally well, particularly when the package is to be transported directly, by a single mode of transportation, over a short distance from the generator to a disposal site, would undermine the voluntary compliance effort. The data presented in Table 1 serve to demonstrate not only the expense of specification packaging, but also the wide range of prices for various containers.

As an example, it should be emphasized that a very popular type container, the 17E and 17H 55-gallon drum, can be obtained as a reconditioned drum at an approximate saving of 35%. Compared with prices of $13.95 and $17.40 respectively for new drums, reconditioned 17E and 17H drums cost about $9. and $11.30, or about 65% of the new container.

As important as reducing the financial burden on the generator, and ultimately on the public, is conserving the energy and material resources required to manufacture the containers. The significance of the energy input in the manufacture of container materials is brought home by the following data. It takes, for instance, 4.624 million btu, to make a metric ton of steel from virgin materials using the basic oxygen process

TABLE 1

UNIT PRICES FOR DOT SPECIFICATION SHIPPING CONTAINERS [1/]

DOT Spec.	Container Capacity	Unit Price [2/]	Comments [3/]
3A	80 cu. ft.	$ 64.30	
3AA	250 cu. ft.	86.75	
3AA	40 cu. ft.	38.45	
3A480X	150 lb. Chlorine	96.70	in orders of 1,000 or more
3HT	265 cu. ft.	86.80	in orders of 500 or more
4AA480	150 lb. Ammonia	147.40	
4B	260 lb. H_2O	100.00	
4BA	123 lb. H_2O	52.50	
4BA	48 lb. H_2O	11.25	
4E	48 lb. H_2O	30.00	
5	55 gal. H_2O	38.00	in orders of 250 or more
5A	55 gal. H_2O	133.00	12 gauge
5B	55 gal. H_2O	20.45	
5C	55 gal. H_2O	195.00	stainless steel
6A	55 gal. H_2O	133.00	12 gauge
6B	30 gal. H_2O	19.00	
6D	55 gal. H_2O	38.60	
6K	55 gal. H_2O	500.00	reconditioned, nickel barrel
6K	55 gal. H_2O	1,200.00	new, nickel barrel
8	140 cu. ft.	61.95	
8AL	255 cu. ft.	97.50	
17C	55 gal. H_2O	18.10	
17E	55 gal. H_2O	15.50	18 gauge
17E	55 gal. H_2O	13.95	20-18 gauge
17F	55 gal. H_2O	22.00	
17H	55 gal. H_2O	17.90	
17X	55 gal. H_2O	15.55	
21C	55 gal. H_2O	16.25	in orders of 200 or more
37A	55 gal. H_2O	12.70	22 gauge
37A	55 gal. H_2O	11.25	24 gauge
37B	55 gal. H_2O	12.70	22 gauge
37B	55 gal. H_2O	11.25	24 gauge

TABLE 1. UNIT PRICES FOR DOT SPECIFICATION SHIPPING CONTAINERS (Cont.)

DOT Spec.	Container Capacity	Unit Price	Comments
37C	5 gal. H_2O	1.64	
37D	55 gal. H_2O	12.80	
37M	55 gal. H_2O	31.90	
39	30 lb. H_2O	5.00	
39	55 lb. H_2O	8.00	
42B	55 gal. H_2O	100.00	reconditioned

1/ Sources of prices may be found in Appendix C.

2/ Except where otherwise noted, prices are based on purchases of 100 or more containers.

3/ It is important to note that many of the less common and generally more expensive DOT specification packagings are only available on a very limited basis. In fact, there are no known manufacturers of certain of the DOT specification containers.

furnace.[1/] To make a metric ton of aluminum from virgin materials requires 59.2 million kcal. The energy required to make a metric ton of paperboard from virgin fiber is between 10.3 and 10.9 million kcal., and for a net ton of glass containers, also from virgin materials, the requirement is 4.385 million kcal. Clearly, a small reduction in the amount of steel, aluminum, paperboard, or glass required for a hazardous waste container would result in tremendous industry-wide energy savings. Allowing limited reuse of DOT single trip containers and unreconditioned non-reusable containers, as recommended elsewhere in this report, would likewise result in a significant reduction in both the energy and cost components of disposing or recovering the waste.

It is beyond the scope of our research to determine which DOT specifications could be substituted for by less costly and less resource consuming packaging. Inevitably, this determination must be preceded by tests to assure the integrity of the principal aim of the required regulations, namely the protection of human life, property, and the environment. We do, however, express the considered viewpoint that significant cost and resource savings opportunities exist.

[1/] Sources of energy requirements for steel, aluminum, paperboard, and glass are contained in Appendix B.

C. Container Recommendations

1. Scope of Hazardous Waste Transportation. At the outset of this section, it is imperative to recognize and deal with the multi-dimensional aspects of hazardous waste transportation and the different categories of waste. Addressing the first aspect, as already noted in this report's first chapter, EPA's concerns encompass three distinct transportation purposes. These are transportation from generator to:

(a) treatment facility,

(b) storage facility,

(c) disposal site.

In both (a) and (c), storage prior to treatment and disposal, respectively, may be involved. If that were to be the case, however, such storage would occur in a "controlled environment." That is to say, as distinct from a public warehouse where all types of products, including hazardous wastes, might be stored, the treatment plant and the disposal facility are operations to be regulated under Section 3004 of the Act and as such would be controlled. The implication is that for storage of wastes at such controlled facilities, the burden of achieving adequate protection is not the generators' or the transporters'. Further, it follows that if different packaging (and labeling) standards were to be applied to each of the three transportation purposes, the fact that storage may take place subsequent to transportation to a treatment plant or a disposal site, can be ignored.

The second dimension involves the different types or categories of wastes. Basically, there are those to which DOT regulations apply and those which are not now covered by those regulations. Within both, there are wastes with varying degrees of hazards. As will be seen later in this chapter, we have endeavored to group these into four categories consisting of wastes which are:

(a) most acutely hazardous to people, e.g., explosives Class A and B, etc.;

(b) less acutely hazardous to people than (a), e.g., Class B poisons, corrosive liquids, etc.;

(c) less acutely hazardous to people than (b), e.g., explosives Class C, corrosive solids, currently non-DOT regulated articles including articles hazardous only to the environment, etc.; and,

(d) health hazards not yet regulated by DOT, e.g., carcinogens, mutagens, etc. [1/]

For wastes in category (a) transported to a storage site, where these hazardous substances might be stored for an indefinite period, the most durable and protective packaging is required. At the other end of the spectrum, items in category (c), moving over a relatively short distance by a single carrier to a disposal site, only require packaging with the durability and protective qualities necessary to assure safe containment during the transportation, handling, and short-term storage incident to disposal.

1/ Materials in this category are not regulated by DOT unless they are also flammable, explosive, etc.

We have structured our recommendations in two main categories, viz., the packaging of wastes which are regulated today under the DOT definitions for hazardous materials, and the packaging of wastes that do not meet current DOT definitions. This approach also aims specifically at assuring consistency with HMTA, as required by Section 3003(b) of RCRA.

2. DOT Regulated Materials. The contractor is not aware that there are problems relating to the transportation of wastes classed by DOT as explosives, flammable or nonflammable gases, pyroforic liquids, organic peroxides, Class A poisons, or radioactive materials. It is this contractor's opinion that, when these acute hazard materials are transported as wastes, they should be transported in the packaging now required by DOT for such hazardous materials that are not wastes. These materials all possess inherent extreme hazard characteristics independent of their packaging, and whether transportation is short-term or long-term, the acute hazards posed to people are ever present and immediate, should an accident occur. In other words, time of exposure is not as great a factor in the safety concern for these materials as it is with some of the others, because of inherent instability characteristics or pressure.

Class C explosive waste, however, could be handled like flammable solids. DOT flammable and combustible liquids, flammable solids, oxidizers, Class B poisons, and corrosive liquids, all could be handled with some degree of relaxation.

since waste transportation of these articles is essentially different from the transportation of valuable chemicals. Waste transportation is of limited duration and typically does not involve the multiple modes of commerce that international freight would involve. The contractor believes that packaging originally built to DOT specifications could be used for such waste materials with some leeway given for the reuse of non-reusable or single-trip packaging (without reconditioning), after suitable inspection by the waste generator. The recommendations following this section depict how the packaging criteria would be applied. It is suggested that criteria be developed to permit the generator to evaluate used DOT packaging for these categories of materials, to assess their adequacy with respect to short-term transportation. This evaluation of adequacy could encompass such tests as visual inspection and leakage, but should not include destructive vibration, drop or hydrostatic testing. Visual inspection should be required for all types of containers for all categories of materials, but leakage testing should be limited to unreconditioned single-trip, non-reusable DOT specification and non-specification packaging.

Where DOT regulations do not require DT specification packaging for hazardous materials, EPA regulations for those materials as wastes should be no more strigent, and use of non-specification packaging should be authrized.

For any hazardous wastes that meet theDOT definitions, and that are DOT-labeled flammable liquids(flash point below

73°F.), "Dangerous When Wet" (water-reactive) flammable solids, oxidizers, Class B poisons, and corrosive liquids, relaxation from the DOT specification packaging rules suggested above only should be authorized for highway transportation that would not exceed 500 miles. The identity of these materials is readily ascertainable from the documentation that will be required to be used, so there should be no difficulty in determining compliance. Where trailer-on-flat-car (TOFC) or rail car operations or water transportation is involved, the current DOT regulations should apply in their entirety without relaxation.

3. Non-DOT Regulated Hazardous Wastes and Certain DOT Regulated Materials. Obviously all of the packaging authorized by DOT could be authorized but need not be required for the shipment of hazardous wastes that are <u>not</u> regulated by DOT. In this category one could also include DOT regulated flammable solids (except "Dangerous When Wet" materials), Class C explosives, corrosive solids, combustible liquids, and flammable liquids with flash points above 73°F., for which there are no current DOT specification packaging requirements.

An alternative to use of DOT packaging that the contractor has carefully examined for these materials is use of the National Motor Freight Classification and Uniform Freight Classification Tariffs. These tariffs are used extensively in the United States by common carriers to describe the type of packaging that they will accept for goods which are offered to

them in transportation. Compliance with the tarrifs assures that the shipper has properly prepared the packaging for transportation, and subsequent losses will not be ascribed prima facie to the packaging. The two tariff classifications are very similar and, for the purposes of this contract, may be considered identical.

It was thought initially that, for hazardous wastes not regulated by DOT, the tariff classifications would provide a source of reasonable packaging guidelines for industry to follow in shipping waste. Closer examination of the classifications, however, reveals that the reliance on these classifications for the adequacy of the packaging could provide a false sense of security. There are numerous packaging rules in the tariffs describing various combinations and categories of packaging. Item 200, for example, is an extensive explanation and description of specifications for bags. Extensive detail is given with respect to the design and structure of the bags. Item 222 provides specifications for fibreboard boxes. Item 257 provides specifications for molded polyethylene drums followed by Item 258, specifications for molded plastic pails. Item 260 offers specifications for aluminum and steel drums. Item 291 includes specifications for fibre drums for dry materials, while Item 296 contains the descriptions and requirements for fibre drums for liquid articles.

The verbiage in these specifications is extensive, but when one examines these specifications recognizing that a number of the requirements do not have any test conditions, that there

is no enforcement staff policing compliance with these requirements, and that the requirements are totally unrelated to the hazardous nature of the product, one must conclude that reliance on these standards may not be totally justified.

Item 260, one main topic covering specifications for steel barrels, gives extensive detail as to the gauge thickness of tops and bottoms of drums, but in discussing heads and tops of containers, the classification says no more than that they "must be securely fastened and filled packages must be proof" against leakage or sifting. There is no leakage test requirement for these drums, no drop test requirement or vibration requirement and, consequently, the control over the quality of the package is not necessarily as stringent as it might first appear. If on looks at Item 200 specifications for paper bags, one finds extensive detail on the number of plies and the weight of paper that must be used, but there are no criteria with regard to the environmental conditions which the package must withstand. Carrying this investigation further and looking at subgroupings of the bags, Items 201 and 202 which cover polyethylene bags state that filled bags must be capable of withstanding six drops from a height of four feet onto a solid surface, one drop on each end, one on each face, and one drop on each side without rupture or leakage. This appears to be a fine performance standard, but there is no agency or organization enforcing these standards, and there are no criteria as to what the material within the bag must be or the weight of it during testing, which all tends to undermine our knowledge of the effectiveness of MHC and UFC packaging.

The intent here is to show that, although the tariff classifications constitute pages upon pages of specifications, one could very well be led astray by adopting such specifications as standards for adequacy of packaging of wastes that are environmentally hazardous. Rather, it would be better to adopt performance-oriented standards that place the onus on the generator to meet basic packaging criteria for the transportation of hazardous waste.

In this respect we refer to Section 173.24 of Title 49 of the Code of Federal Regulations, containing standard requirements for all packages used in hazardous materials transportation. There is nothing in this section contrary to the interests of the EPA in administering the Resource Conservation and Recovery Act. Rather, the section offers a practical guideline to sensible packaging for waste materials. There are some terms in this section that are undefined, such as "normally incident to tra sportation," "significant release," and "effectiveness of the packaging will not be substantially reduced," that could stand clarification. These terms should be clarified by EPA in conjunction with DOT, in light of the products to be packaged, defining with respect to those products what constitutes non-significant release, normal conditions of transportation, etc.

It is the contractor's belief and observation that use of the tariff classification rules for hazardous waste packaging would lead to many administrative problems, but would not enhance safety in transportation or disposal. Packaging that

the generator will use to ship waste is often packaging that he will have on hand. It is our belief that generators neither should nor will go outside their facility to purchase large amounts of new packaging to transport wastes. A realistic approach consistent with conservation will allow the generator to use packaging that he has available at his facility. The fact that the used packaging has arrived at the facility already indicates that it was built to one of two standards, the DOT specifications or the tariff classification rules.

After the generator has removed the original contents, the packaging may be completely usable, in excellent condition, or it may be reduced to scrap because of the process involved in removing the material from the containers. If it is in good condition, then it should be proper to use in transporting and disposing of waste. Creating a new package inventory problem for the generator of waste to dispose of his materials would be contrary to the spirit of the conservation aspects of the act. To find a way to safely use existing resources would be of great benefit. Using an approach similar to DOT's Section 173.24 provides that option.

Given the proper guidelines, generators can effectively assess the adequacy of the packaging that they would use for waste materials. The advantage of this approach is that it places the complete burden on the waste generator to determine the adequacy of the packaging for the materials. Prescribing specific packaging or certain types of packaging by regulation could lead to difficulties if the product is not suitable for

the type of packaging prescribed, or prescribed packaging is not available. These difficulties are much of the source of DOT's exemptions program, which has created many problems for the agency and industry alike. Using performance standards places the onus for adequate packaging completely on the generator, but in turn gives him the flexibility of solving his problems for waste disposal in the most efficient and resource-conserving manner.

4. EPA Recommendations to DOT for Revisions to DOT Packaging Regulations. The contractor's investigations into current DOT packaging needs, as discussed in the preceding sections, have led to the conclusion that EPA should petition DOT to make the following revisions to DOT packaging regulations.

(a) Require that all waste materials regulated by DOT in the following classifications continue to be packaged in DOT specification containers now provided in 49 CFR Parts 173 and 178:

- Explosives, Classes A and B.
- Compressed gasses, flammable and nonflammable.
- Organic peroxides.
- Poisons, Class A.
- Radioactive materials.
- Spontaneously combustible liquids (pyroforics).

(b) Revise current title 49 CFR regulations to add authorization to employ new or used (and not reconditioned) DOT-specification NRC (non-reusable containers) or STC (single-trip containers), for transportation of the following DOT classifications of hazardous material.

when that transportation would be by one motor carrier for a distance of less than 500 miles:

- Flammable liquids (flash point less than 73°F.).
- Flammable solids (bearing the "Dangerous When Wet" label).
- Oxidizers.
- Poisons, Class B.
- Corrosive liquids.

The generator would have to subject all used (and not reconditioned) packaging to a detailed visual examination. In addition, he would have to subject each used (and not reconditioned) packaging for liquid wastes to a 5 psig pressure test. No containers observed to be defective or leaking would be authorized for use.

(c) Revise current title 49 CFR regulations as necessary to authorize any suitable DOT-specification packaging or non-specification packaging, meeting the general requirements of 49 CFR 173.24, for the shipment and disposal of wastes meeting the following DOT classifications:

- Flammable liquids (flash point of 73°F. or higher).
- Flammable solids (except those bearing "Dangerous When Wet" label).
- Explosives, Class C.
- Corrosive solids.
- Combustible liquids.

(d) Revise DOT hazardous materials regulations to institute necessary transportation and packaging requirements for carcinogens, mutagens, teratogens, genetically active materials and biologically reactive materials such as those that would induce convulsions, labor or

other human physical reaction upon brief exposure to transportation through inhalation or skin contact).

In addition, the contractors would make the following recommendations for EPA adopted packaging regulations:

(a) Promulgate a general rule in EPA regulations, adopting, by reference, the DOT regulations (as revised according to the EPA recommendations noted above) for applicability to those hazardous waste materials defined under the Resource Conservation and Recovery Act that also meet the DOT hazard definitions. This will facilitate EPA enforcement actions against hazardous waste generators who should use DOT specification packaging but do not, and removes the necessity for complete reliance on DOT enforcement. Of course, a provision or understanding between the agencies should bar the possibility of both agencies instituting enforcement action against the same generator or transporter for the same shipment.

(b) For all materials regulated by EPA as hazardous wastes that do not also meet the criteria of DOT hazardous materials definitions, adopt as EPA regulations the general performance packaging requirements set forth in current 49 CFR 173.24.

IV. Hazardous Waste Labeling and Marking

A. DOT Labeling and Marking Requirements. DOT, in addition to specifying the packaging which must be used for the transportation of hazardous materials, also requires certain product markings and warning labels to be placed on the packages. Also, DOT shipping paper requirements under the HMTA encompass the shipping manifest. DOT regulations also require placarding of certain vehicles used to transport certain DOT-regulated hazardous materials, including those hazardous wastes that meet the definitions in the DOT rules. Placards, or alerting signboards appearing on four sides of certain transport vehicles under the DOT regulations, are devices to communicate brief but vital information to emergency response personnel and the public during the first moments of a transportation emergency. Placarding is not recommended for hazardous wastes that would not currently be placarded under DOT regulations, for the nature of the communication itself is essentially different. The DOT placarding communication is a carefully designed system to communicate abbreviated warning information regarding acute and immediate hazards that could directly impact the people near the vehicle. Any justification for broad identification of an EPA-regulated material would relate more to the proper handling and disposal of the vehicle contents during the more prolonged and controlled period of containment and clean-up of a spill. This communication, however, would necessarily

be in such detail that it would either call for lengthy and varied placards, or a hazardous waste manifest. We believe that the advisory information on the character of the material on the vehicle is best communicated by the manifest, without injecting complexity and perhaps confusion into the emergency alert placarding system developed by DOT to warn people of acute hazards present in the first few moments of a transportation emergency.

There is perhaps some concern as well for potential separation of the shipment from its descriptive manifest, thus risking loss of the identity of the contents of a particular hazardous waste shipment. As described below, every package of hazardous waste would have a descriptive identifier that pairs it with the appropriate manifest description, so that papers and packages that might be separated can be put together again. In the event of bulk shipments, the likelihood of storage or spotting of tanks separate from the tractor in which papers are kept is smaller than the likelihood of packages being separated from their trailer, In any event, other tank markings, tag numbers, and identifiers will enable the hazardous waste transporter to match the right paper with the right tank, without necessitating the placement of all the manifest information on a placard on the tank. Although one might contemplate a requirement that the manifest be physically attached to the tank in an envelope or pouch, it is believed that this would enhance the possibility of papers being lost, stolen, or removed by vandals, and therefore this requirement is not recommended. If any requirement is believed necessary, it is recommended that EPA adopt a simple general regulation calling

for the positive control of documents by the transporter when the tank is in his possession, and the pairing of the documents by any means chosen by the transporter such as tank numbers or license tag numbers.

In sum, it is believed that placarding of EPA-defined hazardous wastes that would not require DOT placarding today would be counter productive, imposing an unnecessary and costly requirement on the generator that bears a strong potential for diluting and confusing the existing and developing DOT placarding program.

In accordance with task I and III requirements. current DOT marking and labeling requirements have been investigated, in terms of their suitability for the marking and labeling of packaged hazardous wastes. Our analyses and recommendations follow.

1. DOT Labeling Specifications. For many years, DOT and its predecessor agency the Interstate Commerce Commission, have prescribed specific labeling requirements for packages containing hazardous materials. The applicability of the DOT regulations in 49 CFR is determined on the basis of the hazard of the materials and the fact that the carrier of those materials is engaged in interstate or foreign commerce. As such, waste materials meeting the hazard criteria of regulated articles and carried aboard vehicles operated by carriers engaged in interstate or foreign commerce have been subject to these same labeling requirements. In addition, DOT shipping paper requirements have been applied to common, contract, and private carriers engaged in such commerce for many years. Thus, hazardous wastes meeting the DOT classification

definitions and hauled by regulated carriers have had to be accompanied by DOT shipping papers.

There are seventeen hazard classes or groupings used by DOT to identify the primary hazard of the material. These classes are the following:

1. Explosive.
2. Radioactive material.
3. Poison.
4. Flammable liquid.
5. Flammable solid.
6. Organic peroxide.
7. Oxidizer.
8. Flammable gas.
9. Nonflammable gas.
10. Corrosive material.
11. Irritating material.
12. Combustible liquid.
13. Etiologic agent.
14. Other Regulated Material, ORM-A.
15. Other Regulated Material, ORM-B.
16. Other Regulated Material, ORM-C.
17. Other Regulated Material, ORM-D.

The determination of the appropriate classification is made by reference to the hazardous materials table in 49 CFR 172.101 and by simultaneous review of all DOT hazard definitions to determine if one or more apply to the material. If the class for the material is prescribed by Section 172.101, or if the material is an explosive classed by the Bureau of Explosives of the Association of American Railroads, or if it is an etiologic agent identified by the Department of Health, Education, and Welfare in 42 CFR 72.25(c), or if it is

declared by the regulations to be an organic peroxide, then the prescribed class must be used. It often happens, however, that a material will not have its classification prescribed according to one of these mechanisms and, upon matching its characteristics with the various classification definitions, it is found that the material meets more than one definition. In this instance, one looks to 49 CFR 173.2 to determine by a sliding scale which hazard DOT considers to be primary and consequently, which classification will apply to that material. It is worthwhile to note that the sliding scale shown in Section 173.2 is not a continuum of hazard ranking, but rather, is on a continuum of the quality of packaging and other controls applied to the material in the DOT regulations. Thus, while one might consider Class B poisons to be more dangerous than corrosive liquids, the corrosive liquid class takes precedence, because the packaging for corrosive materials is generally of a higher caliber than that prescribed for Class B poisons.

The class of the material determines which label must be applied to packages containing that material. Multiple labeling would be required in certain instances described more fully below. Generally speaking, only one label must be applied to each package and that label is the one corresponding to the class of the material.

The following specific materials and circumstances are not subject to DOT labeling:

(a) Materials and package sizes specifically granted certain regulatory relief due to the "limited quantity" of material in each inside unit in the packaging. The authorized limited quantity will vary with the hazard of material, the nature of the packaging, and the quantity of material in the package. One should review the limited quantity paragraphs preceding each subpart of 49 CFR Part 173 for details. It should be noted that there is a limited quantity section for most classes, and relief from DOT labeling is granted to all such materials except poisons.

(b) Certain compressed gas cylinders shipped in private carriage and bearing the smaller DOT decal label developed by the compressed gas industry.

(c) Military ammunition shipped by or to the military in carload or truckload lots.

(d) Other hazardous materials shipped and carried by the military.

(e) Permanently mounted gas cylinders on vehicles, such as tube trailers.

(f) Portable tanks that are placarded.

(g) Freight containers larger than 640 cubic feet.

(h) Any materials in the ORM classifications.

(i) Packages containing combustible liquids, which are not DOT-regulated-in unit quantities of less than 110 gallons, and would have to be placarded (not labeled) in quantities above 110 gallons.

(j) Certain low specific activity radioactive materials.

(k) Cargo tanks and tank cars that would be subject to placarding, not labeling, requirements.

Each package requiring a radioactive material label must bear <u>two</u> such labels, affixed to opposite sides of the package. Certain hazardous materials are considered to be of such a

nature as to require labeling for more than one classification. Every Explosive A, Poison A, or labeled radioactive material that also meets the definition of another class must be labeled for each class. These labels should be displayed next to each other. Dual class labels are also required for many poisons that also would meet certain other class definitions.

Certain larger containers, although not sufficiently large to require placarding, are subject to a two-label requirement because of their size. These are shown in 49 CFR 172.406(e).

The current DOT labels are shown in Appendix D. In addition to the labels for each hazard class are certain additional visual requirements that loosely could be called labels and have unique uses, namely the Cargo Aircraft Only, Magnetized Material, Etiologic, Bung, and Empty labels. Generally speaking, however, and in this report, the word "label" under the DOT regulations is defined to mean the diamond-shaped, color-coded labels having a dimension of at least 4" x 4".

The DOT labels have five principle ingredients: color, size, shape, international symbology, and key word or legend. These labels are compatible with the UN recommendations on hazard labeling, although the legend may vary from nation to nation due to language differences.

Any label is a communicating device. Any effective communication must have a recipient and the recipient of the communication should have his behavior affected accordingly.

In examining the issue of labeling for hazardous waste, it is important first to identify the recipient of the communication, and then identify the actions the communication should cause him to take.

As noted earlier, the DOT hazardous materials regulations are designed to control acute hazards in the transportation environment. The population of those intended to be protected by these regulations includes the general public, but especially when one is discussing labeling of packaged freight, the people to be protected by these regulations are industrial employees: employees of the shipper, forwarder, carrier, and consignee. Indeed, since the labels applied under the DOT regulations are on the industrial packaging used in transportation, few members of the general public ever see them. Accordingly, it is reasonable to assume that the audience for the message communicated by the DOT labels are those in the transportation work force.

The people intended to react to the labels are those who pack the material, who handle the packages in loading, unloading, and storage, and who operate conveyances carrying the packages. To a very limited extent, the labels are communication to emergency response personnel in the transportation environment, but primary communications to such personnel are conveyed by shipping documents (the manifest) and placards.

The message of these labels is brief, providing a warning of the presence of hazard and a general signal of the nature

of the primary hazard. Before adoption of labels corresponding to the UN recommendations and developed over a period of many years in the international forum, DOT had labels conveying much more detailed information on the hazard and handling requirements relating to it.

Appendix E is copied from the 1971 edition of 49 CFR and illustrates labels that had been in use for many years. Reference to this Appendix will confirm that, although much more detail appeared on the labels, the communication itself is much less effective due to the clutter. The new labels were adopted by DOT after a long rule making in their Docket No. HM-8. In that rule making, it was proposed that the top half of the labels conform to the standard UN format, and that the bottom half of those labels convey all the detail of the old labels plus certain additional advisory messages, such as "Wash hands thoroughly after handling."

Publication of amendments in Docket No HM-8 took place in the Federal Register of February 27, 1973. DOT dropped that portion of the proposal that would have placed the words "Danger", "Warning", or "Caution" on the labels, noting that these advisory messages would actually conflict with similar warning words prescribed by the Food and Drug Administration. DOT concluded that information was needed with regard to handling and emergencies involving hazardous materials, but expressed "doubt whether this detailed information should be included in the primary warning label."

None of the suggested and proposed advisory language was adopted by DOT. They declared: "The (Hazardous Materials Regulations) Board recognizes the limitations on placing detailed handling and emergency procedure information on labels and has decided that the information should not be included on the labels due to space limitations precluding the use of such information in a beneficial manner."

The DOT labels, therefore, are not devices to communicate an encyclopedia of information regarding the product, but rather, communicate "'alert' words or short phrases. Long, 'small print' statements are likely to go unread." (Docket No. HM-8, Notice No. 70-13, July 22, 1970, F.R. 11742, republished at page 458 of Bierlein's Red Book on Transportation of Hazardous Materials.)

These alert words trigger an awareness of the presence of the hazard in transportation. They also play a key role in triggering certain operational requirements under the DOT regulations. For example, placarding requirements for Class C explosives only apply to products bearing such a label (49 CFR 172.504 Table 2); placarding does not apply to "limited quantities," defined in 49 CFR 171.8 as "the maximum amount of a hazardous material for which there is a specific labeling and packaging exception" (49 CFR 172.500(a)(3)); "a carrier may not transport a package bearing a poison label in the same vehicle with material that is marked as or known to be foodstuff, feed or any other edible

material intended for consumption by humans or animals" (43 CFR 177.841(e)); materials granted relief from labeling in the various limited quantity exception paragraphs in the DOT regulations are also exempted from all of Part 177 except shipping paper requirements, so unlabeled articles need not be stowed or handled in highway transportation in any special manner, although their presence and quantity must be noted on shipping documents kept accessible to the driver in the cab of the vehicle.

In sum, the DOT label advises of the primary hazard of the material and signals the carrier to implement placarding and other operational requirements vital to maintaining safety in commerce. It is extremely important to note that any EPA mandate to use DOT labels in circumstances where DOT does not call for their use would inject extreme confusion into the transportation safety regulatory system.

2. DOT Package Marking Specifications. The majority of the Department of Transportation's hazardous materials package marking requirements are published in 49 CFR Part 172. In general, the shipper of such packages must mark the "proper shipping name" of the material on each package. The proper shipping name is that entry in the alphabetical commodity list in 49 CFR 172.101 that most accurately and specifically describes that material. There are no current entries for materials specifically identifying them as wastes, except for certain goods retaining some commercial value that are

transported for recovery of ingredient products, e.g., "waste paper, wet," or "waste wool, wet."

In addition to the requirement to mark the name of contents on the packaging, certain advisory markings such as "This End Up" are prescribed in Part 172. If the container is a DOT specification packaging, the numbers and letters indicating that specification also must be marked on the package, these are normally marked or imprinted by the manufacturer of the container. These specification container markings are a certification by the maker of that container that he has met the detailed requirements of Part 178 of the DOT regulations.

As indicated in the portion of this report dealing with DOT specification packaging that would be prescribed for certain materials covered by draft EPA definitions of hazardous waste, the proper shipping names would be the broadest generic description provided by the list in 49 CFR 172.101, namely, the description of the hazard followed by the initials indicating a more specific name is "not otherwise specified," e.g., "Flammable liquid, n.o.s.," or "Corrosive liquid, n.o.s."

Marking, as that term is used in the DOT regulations, is distinct from labeling. The label is the 4" x 4" color-coded diamond that shows the class of the material by international symbol and English descriptive word. For waste materials that meet the DOT hazard definitions, therefore, the marking of the shipping name and the descriptive word of the class on the label are somewhat redundant. Thus, a material under

the shipping name "Flammable liquid, n.o.s." will also bear the "Flammable liquid" label bearing the international flame symbol. It is recommended that this redundancy be eliminated by EPA petitioning DOT to remove the requirement to mark the name of contents on containers of wastes in the following DOT regulated categories: Class C explosives, flammable liquids with flash points of 73°F. or higher, flammable solids (other than those bearing the "Dangerous When Wet" label), and corrosive solids.

3. DOT Labeling Performance Specifications. As important as the markings on the labels, in terms of effectively communicating a warning to individuals coming into contact with the container, are the performance standards which the label is expected to meet. If a label is separated from a container, or if the symbols and markings fade, the message is lost. Accordingly, we have investigated certain aspects of the current DOT hazardous warning labe manufacturing process in order to ascertain an approximation of the length of time that such a label might be expected to survive.

The Department of Transportation, in 49 CFR 172.407, specifies that the diamond label is to be at least four inches on each side, with each side having a black solid line border 1/4 inch from the edge. The label may be either affixed to or printed on the package, must be durable and weather resistant, and must have wording and symbols conforming to the specifications of 49 CFR 172.411 to 172.444. Colors are

specified in 49 CFR, Part 172, Appendix A and B, and must be capable of withstanding a 72-hour fadeometer test as well as withstanding open weather exposure for at least 30 days without a substantial reduction in effectiveness. The method of manufacturing the label, the type and weight of label stock, and the type of adhesive are not specified.

Paper and vinyl are two of the more commonly used label stocks. A standard paper label stock is 60 lb. clay cast coated paper with a 40 lb. peel off liner to protect the pressure sensitive adhesive. For greater durability an acrylic film of .005 cm to .007 cm thickness is used rather than the 60 lb. paper.

The most durable and commonly used pressure sensitive adhesives are the acrylic and urethane compounds. The contractor found no empirical data indicating the length of time that the adhesive might be expected to hold the label in place, and estimates by the manufacturers ranged from six months to ten years depending on the environment the container is exposed to, and the type of adhesive used.

As important as the adhesive is the type of ink used in printing the markings on the label. Generally either an alcohol base ink or an acrylic paint will be used, depending on whether the printing process is by roll press or silk screen. In order to increase the durability of the label it may be laminated with certain protective compounds. One such material, "Tedlar," is estimated to increase the life

of a label from five years unlaminated to twenty years laminated, though the cost of the label would increase from $0.03 for an unlaminated vinyl label to $0.08 for the laminated version. Another material, "Mylar," was estimated to protect a paper label for about ten years, but would also add between two and three cents to the cost of each label.

It is important to keep in mind that the manufacturers' estimates of the useful life of the label assume conditions likely to be found during normal transportation. No comparable estimates were available for the peculiar conditions likely to be encountered during prolonged, exposed storage or burial in a waste disposal site. It is known, however, that extremes of either cold or heat will result in adhesive failure over time and long periods of exposure to direct sunlight will cause the inks to fade. As was suggested in the discussion of container longevity, long term technical studies would have to be undertaken to determine the effects that the conditions of prolonged storage and disposal will have on the labels, if that information is determined to be necessary.

B. EPA Hazardous Waste Labeling and Marking Recommendations.

1. General Discussion. Regulations to be adopted by EPA pursuant to its mandate under RCRA may apply package labeling to materials, i.e., wastes defined by EPA as hazardous. Such wastes, as noted before, may or may not be regulated by DOT today. Definitions developed to date by EPA appear to include most materials regulated by DOT but also include a wide range of materials not so regulated.

A careful review of the rationale and background papers and incidents leading to broader definitions of various waste classifications reveals a predominant concern with the hazard at the disposal site, rather than in transportation. Thus, in the definition of flammability, the flash point limit of 140°F. is supported by examples of temperatures achieved at disposal sites either from heat of operating equipment, chemical reactions of adjacent waste materials, or prolonged atmospheric heating at the site. he corrosive materials definition developed by EPA expresses a concern with acute impact that is regulated by DOT but, in addition, raises concerns with disparities between the pH of waste materials and land fills and water sources at the disposal site.

In prescribing EPA hazardous waste labeling and marking specifications, as well as performance standards, it is important to keep in mind the inherent distinctions between the conditions likely to be encountered by waste containers transported to a treatment facility, a storage site, or a disposal site.

In the sections following, we shall deal with these various situations after first addressing the broader subject of performance standards.

2. Performance Standards. The conditions and length of time that a label would be expected to survive on a container being transported from a generator to a treatment facility would probably be very similar to those encountered during the normal distribution of hazardous materials. Even if the container were subject to a period of temporary storage at the treatment site, whether in a sheltered or an open weather environment, the length of time would still probably not be so great as to result in a significant reduction in the label's effectiveness. As has been noted in a preceding section, DOT warning labels are already required to withstand a 72-hour fadeometer test and 30 days of open weather exposure and this performance requirement should be adequate for labels used on containers for transportation per se.

The time and environmental considerations for a labeled container transported to a disposal site are different and, to a large extent, unknown. As has been noted previously, there has been no empirical research into the destructive effects that prolonged burial would have on a container label, nor is there a clear understanding of the length of time that label information would be expected to survive. Certainly the label would be expected to survive the period of waste containment but, as was mentioned in the discussion of container

shelf-life, even this factor is presently largely unknown. In order to specify meaningful performance standards for disposal container labels, long term technical studies would have to be undertaken to determine the destructive effects that prolonged burial will have on container labels. In the meantime, it is not unreasonable to assume that higher performance standards than those currently required by DOT would be necessary if it became desirable to assure that the package can be properly identified some years after it has been buried. An alternative to this, applicable to metal containers, might be to require that the warning be embossed on the outside of the container.

Transportation to an intermediate storage facility poses still another set of time and environmental considerations. If the stored waste is intended for later recovery, then it is unlikely that the period of storage would be so great as to preclude the use of labels meeting the current DOT performance standards. On the other hand, if the waste is ultimately to be disposed of, particularly if the storage is at a disposal site, and if intact container retrieval were considered necessary, then it would be appropriate to use a label which would meet the higher performance standards necessary for labeling disposal containers.

3. Recommendations.

3.1 General Approach. Unnecessary redundancy in regulatory requirements provides a disincentive to compliance. Also,

EPA has a unique additional jurisdictional authority that is lacking at DOT, i.e., direct regulatory control over the recipient of waste. DOT does not have authority over the recipient of hazardous materials unless that recipient has participated in or in some real way has caused the transportation of the hazardous materials. Through this direct EPA regulatory control, it is assumed that operators of waste disposal sites under permits will have certain record keeping responsibilities, including a log of materials received and where those materials are stored or have been buried. Given the concern with hazardous wastes at the disposal site, this element of control will allow for the maintenance of records in sufficient detail to identify not only the location of waste materials, but the characteristics of those materials as identified by the manifests accompanying the materials to the disposal site. This control over the site operator will enable EPA to prescribe that materials of certain incompatible natures not be buried together, or materials with certain pH values not be buried at all in that location.

It is established fact that products which, in the event of container failure, pose an immediate threat of bodily harm and property destruction are regulated by DOT. For these types of wastes, the DOT labeling and marking regulations apply. Regardless of the purpose for waste transportation, it can be reasoned that the "alert" signals now prescribed by DOT should continue to apply to such highly hazardous wastes.

This can be accomplished by EPA's adoption of title 49 labeling requirements by reference to waste products which possess DOT defined hazards of flammability, corrosion, etc., during transportation. Thus, the DOT hazard label will perform the function for which it was designed, namely, to communicate to persons engaged in transportation and handling of such materials the existence of a potential peril to themselves, the property in their custody, and that surrounding their transit route.

Thus, regardless of the purpose for which an acutely hazardous waste is being transported, it is concluded that the DOT prescribed warning label should continue to be required, for its alert message is deemed to be an imperative "notification" irrespective of the mode of transport employed and the distance of transportation.

3.2 Non-DOT Regulated Wastes. As noted earlier in this report, hazardous wastes not now regulated by DOT do not pose the same immediate peril to human health and property. Their principal adverse effect is upon the environment and it is for that reason that their transportation, disposal, storage, and treatment shall be regulated.

The need for an alert label for attachment to the container bearing these less acutely hazardous wastes is believed to exist. This need should be met by a single version warning label or marking, such as the "E" label shown in Figure 1 following. Similar to the DOT prescribed hazardous materials warning labels, this label or marking fulfills the

Figure 1

PROPOSED HAZARDOUS WASTE WARNING LABEL

function of alerting all persons involved in handling and transporting the waste containing package that it contains a potentially hazardous material. It further conveys the message that for the "E" labeled package, shipping papers (manifest) fully identifying the contents have been prepared and, in the event of spills, leakage or any other problems encountered with the packaging, those shipping papers must be consulted.

The considerations weighed in developing the "E" label or marking include the following:

(a) A round configuration was selected to conclusively avoid prohibited confusion with existing diamond and rectangular shaped DOT labels. In addition, it is likely that a round shape will be distinct from brand name labels that more frequently are rectangular.

(b) The "E" is in lower case and is representative of the environment; it is surrounded by the internationally-recognized red border and bar, indicating that open disposal of this material in the environment is prohibited.

(c) In addition to the lower case "E" being commonly associated with the environment, it has the benefit of looking like the letter "E" even though the label may be applied upside down. Upside down capital E's could be confused with the numeral "3".

(d) It is recommended that while a minimum size may be prescribed to assure visibility, no maximum size of this label or marking should be prescribed, thereby allowing the user to adopt the size best suited to covering existing markings, adapting to other materials printed on the container, container size, and the like.

(e) The border and prohibitive bar across the label or marking should be red, for the sake of international recognition. It is not necessary to describe the color in great specificity, and any attempt to do so will result in added effort without commensurate benefit for those who may print the "E" label on surfaces that will affect the color, such as kraft paper. The "E" itself may be any color, but if it is the same red as the surrounding border, then black lines should be used to demark the points of intersection of the bar with the letter.

It is further recommended that, in applying the new "E" labeling or marking system, EPA incorporates a limited quantity exception, comparable to DOT's limited quantity labeling exceptions in 49 CFR 173.118, 173.244, etc. Thus, small package units would not bear the "E" label or marking, preserving the impact that signal should have by avoiding the appearance of it when the package quantity does not justify regulatory concern.

Finally, it is recommended that for the "E" label or marking a simple performance standard for durability be incorporated in the regulation. EPA also should require storage site operators to replace deteriorated labels or markings on products in long term storage (not disposal).

The DOT warning label and the "E" label or marking are intended to be communications to the hazardous waste transporter and the treatment, storage, or disposal site operator. As such, there is no need for use of such communications on

hazardous waste containers kept or disposed of on the generator's premises. If there is any need for a warning system at this juncture, it is more appropriately a concern for the Occupational Safety and Health Administration of the Department of Labor. If the generator desires to warn present or future employees of the hazards of the contents of waste containers in long-term storage, the American National Standard for the Precautionary Labeling of Hazardous Industrial Chemicals set forth in ANSI-Z 129.1-1976 is recommended, in lieu of using either a DOT or EPA developed labeling or marking system.

4. Marking. Consistent with our recommendation to authorize the reuse of packaging on hand for the disposal of many DOT regulated commodities, as well as those regulated by EPA but not DOT, and since the proper shipping name of the waste material will not already appear on such packaging but would have to be applied, it is recommended:

(a) that EPA <u>not</u> require the marking of the name of contents on any articles that are not DOT regulated; and,

(b) that EPA petition DOT to remove the requirement to mark the shipping name on DOT labeled containers or waste meeting the following DOT classifications:

- Flammable liquids (flash point 73°F. or higher).
- Explosives, Class C.
- Flammable solids (except those bearing the "Dangerous When Wet" label).
- Corrosive solids.

To avoid confusion that might result from allowing the

marking of the previous contents of a used (but not reconditioned) container, when that marking does not correspond to the hazardous waste put into the used container for disposal purposes, it is recommended that generators remove, obliterate or cover the misleading marking. The "E" label or marking could be used for the purpose of covering the misleading name of the previous contents of the container.

An additional recommendation is development of a mechanism to allow the proper pairing of waste containers with their shipping papers. As noted before, considerable reliance must be placed on the detailed product descriptions contained in the manifest for the particular characteristics of the hazardous commodities. This "pairing" of container and manifest may be needed subsequent to transportation for any of the ultimate purposes and in particular when long term storage and disposal occur.

It is recommended that this correlation between packagings and manifests be accomplished through common markings on each. Such common markings should be expressed in a numeric or alphanumeric identifier affixed to or inscribed on the container.

The generator of the waste material who prepares the manifest and also prepares the material for transport, clearly is the person best suited to apply the package markings and to so note the manifest. A proliferation of identifiers will result, however, if each generator invents his own system

of letters, numbers, and alphanumerics to identify each container. This proliferation will wreak havoc on the inventory control system administered by the disposal site operator.

Accordingly, it is recommended that the disposal site operator devise his own system of identification, using a limited number of letters, numbers, or both. Before a waste material would be consigned to its disposal site, a contact from the generator would be made, and the site operator would assign a range of identifiers to that shipment. The generator then would mark these identifiers on each package and on the appropriate description of the contents of that package shown on the shipping paper. This pairing would minimize the danger of mixing packages from one generator with those of another, and would permit ready distinction between various containers in a mixed shipment from the same generator.

If a generator commonly used the same disposal site and made frequent use of the services of that site, a block of identifiers could be assigned to that generator for his use, eliminating the need for telephone contact before each shipment, but also eliminating the possibility that two generators would apply the same identifiers to their packages.

It is not believed to be necessary that specific instructions be expressed in EPA regulations regarding the details of the marking of the identifier on the packages. It is recommended that the general requirements of 49 CFR

172.304 be paraphrased:

> The marking must be durable and printed on or affixed to the surface of a package or on a label, tag, or sign. It must be displayed on a background of sharply contrasting color. The marking may not be obscured by labels or attachments to the package.

APPENDIX A. ABSTRACTS OF A CROSS SECTION OF TECHNICAL STUDIES DEALING WITH DOT PACKAGING PERFORMANCE STANDARDS

Report No.: TES-20-74-7

Report Title: "Development of Performance Oriented Specifications for Drums and Pails Used for Packaging of Hazardous Materials for Transportation"

Authors: C.E. Fridinger, C.V. Vickers, Jr., J.S. Gott

Date: December 2, 1974

Abstract: A study was carried out to develop performance requirements and tests for drums and pails used to ship hazardous materials. The current requirements and tests were obtained by studying DOT regulations and other standards and specifications on drums and pails. Reports of the hazards of shipping and the tests used in the packaging industry were also studied. Hazard classifications, performance requirements and tests, and a container rating system were developed. The rationale behind the development is presented in the report. Test plans for Qualification and Periodic testing and detailed test procedures were prepared. Tests included were Leak, Distortion, Pressure-Proof, Repetitive Shock (Vibration), Wet Strength-Stacking, Drop, and Puncture Tests and a Temperature Cycle. Tests are recommended for loaded containers over the temperature range of -20° F. to 130° F. The temperature cycle on empty containers covers the range of -20° F. to 160° F. A representative sample of drums and pails now regulated by DOT was subjected to the test program. Details of the test results are included in this report.

This report does not relate to container shelf-life.

Report No.: DOT/MTB/OHMO-76/4

Report Date: October, 1976

Title: "Performance of Plastic Packaging for Hazardous Materials Transportation: Part I Mechanical Properties"

Authors: John M. Crissman
Charles M. Guttman
Louis J. Zapas

Abstract: This report, prepared for the U.S. Department of Transportation, contains background information useful in evaluating the performance of plastic packagings for hazardous materials transportation, insofar as mechanical properties are concerned. Current DOT regulations and test methods are reviewed, as well as testing procedures from other organizations to modify current DOT regulations to make test methods more quantitative. Finally, experimental data are presented which represent the initial stage of a study it is hoped will ultimately lead to the establishment of criteria upon which the long range behavior of plastic containers can be predicted based on short range tests.

Report No.: DOT/MTB/OHMO-76/5

Report Date: October, 1976

Title: "Performance of Plastic Packagings for Hazardous Materials Transportation: Part II - Permeation"

Authors: John D. Barnes
Gordon M. Martin

Abstract: Permeation as a mode of failure for plastics packagings is discussed. The materials properties which determine permeation performance are defined. Measurement methods aimed at determining values for the materials properties are surveyed.

A "matrix" scheme is introduced for evaluating the risks associated with the permeation failure of a package containing a hazardous materials lading. Permeation factors influencing reuse of plastic containers are described. Laboratory data from an evaluation of a simple method of test for estimating the intrinsic property of a lading to permeate polyethylene is presented.

APPENDIX B. SOURCES OF ENERGY REQUIREMENTS DATA FOR STEEL, ALUMINUM, PAPERBOARD, AND GLASS

1. Steel. Yaksich et al., Environmental Impacts of Virgin and Recycled Steel and Aluminum, Calspan Corporation, for OSWMP-EPA, 1974.

2. Aluminum. Yaksich et al., Environmental Impacts of Virgin and Recycled Steel and Aluminum, Calspan Corporation, for OSWMP-EPA, 1974.

3. Paperboard. Arthur Purcell and Fred L. Smith, Jr., Assessment of Impacts from Materials Production and Use of Resources and the Environment: A Review of Reports, EPA, edited drafts, 1976.

4. Glass. Energy Use Patterns in Metallurgical and Nonmetallic Mineral Processing, Phase 4--Energy Data and Flow Sheets, High Priority Commodities, by Battelle Columbus Laboratories, Bureau of Mines, 1975.

APPENDIX C. SOURCES OF DOT SPECIFICATION CONTAINER PRICES

DOT Specification	Price Source
3A	Taylor Wharton Cylinders
3AA (250 cu.ft.)	Taylor Wharton Cylinders
3AA (40 cu.ft.)	Pressed Steel Tanks
3A480X	Pressed Steel Tanks
3HT	Pressed Steel Tanks
4AA480	Pressed Steel Tanks
4B	Pressed Steel Tanks
4BA (123 lb. H_2O)	Pressed Steel Tanks
4BA (48 lb. H_2O)	Worthington Cylinders
4E	Worthington Cylinders
5	U.S. Steel
5A	General Container Corporation
5B	Inland Steel
5C	Inland Steel
6A	General Container Corporation
6B	General Container Corporation
6D	General Container Corporation
6K (reconditioned)	General Container Corporation
6K (new)	General Container Corporation
8	Norris Industries
8AL	Coyne Cylinders
17C	Rheem Steel
17E (18 gauge)	Inland Steel
17E (20-18 gauge)	Rheem Steel
17F	General Container Corporation
17H	Inland Steel
17X	Rheem Steel
21C	Allied Chemical

DOT Specification	Price Source
37A (22 gauge)	Inland Steel
37A (24 gauge)	Inland Steel
37B (22 gauge)	Inland Steel
37B (24 gauge)	Inland Steel
37C	Inland Steel
37D	Inland Steel
37M	General Container Corporation
39 (30 lb. H_2O)	Worthington Cylinders
39 (55 lb. H_2O)	Worthington Cylinders
42B	Allied Chemical

APPENDIX D - CURRENT DOT SPECIFICATION
WARNING LABELS

hazardous materials labels

IN COMPLIANCE WITH D.O.T. SPECIFICATIONS

40-410

40-430

40-425

40-415

40-435

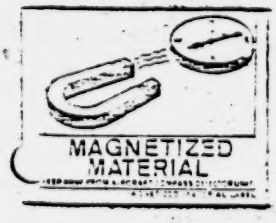
40-460

40-420

40-475

40-455

THESE TWO LABELS ARE REQUIRED FOR CERTAIN DOMESTIC AND INTERNATIONAL AIR SHIPMENTS.



40-500

40-505

THESE TWO LABELS IN ADDITION TO THE DANGEROUS WHEN WET LABEL ARE OFTEN REQUIRED ON EXPORT SHIPMENTS.

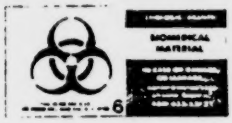
40-481

40-510

40-440

40-470

40-485



40-490

40-445

40-465

40-515

EMPTY

40-495

40-450

40-480

APPENDIX E - OLD DOT LABELS, COPIED
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APPENDIX F- PERSONS, ORGANIZATIONS, AND BUSINESSES CONTACTED

Allied Chemical, Morristown, NJ
Mr. S. Kuzma

Aluminum Association, Washington, D.C.
Mr. S. Epstein
Mr. B. Pritsky

Aluminum Recycling Association, Washington, D.C.
Mr. R. Cooperman

American Animate, Wayne, NJ
Mr. D. Kelly

American Paper Institute, New York, NY
Dr. R. Calkins
Mr. J. Duke
Mr. R. Olson

Arnold Factory Supplies, Inc., Bladensburg, MD
Mr. E. Daniels

Association of American Railroads, Washington, D.C.
Mr. R. M. Graziano

Automotive Trade Association, Washington, D.C.
Mr. W. Johns
Mr. D. Doyle

Can Manufacturers Institute, Washington, D.C.
Mr. K. Helsing

Continental Can Corp., New York, NY
Mr. G. Reed

The Council for Safe Transportation of Hazardous Articles, New York, NY
Mr. M. Smith

Coyne Cylinders, Huntsville, AL

E. I. DuPont de Nemours and Co., Wilmington, DE
Mr. R. E. Lunn
Mr. J. Stevens

Essex Chemical, Monmouth Junction, NJ
Mr. D. Cunningham

The Fertilizer Institute, Washington, D.C.
Mr. K. Johnson

Fibre Box Association, Chicago, IL
Mr. A. W. Hoffman
Mr. T. Muldoon
Mr. D. Rouleau

Fisher Scientific Co., Silver Spring, MD
Mr. J. Curtis
Mr. W. Learn

General Container Corp., Hillside, NJ
Mr. Kapp

Glass Packaging Institute, Washington, D.C.
Mr. J. McGowan
Mr. G. Teitelbaum
Mr. J. Turk

Hazardous Materials Advisory Committee, Washington, D.C.
Mr. G. Wilson

Hollinger Corp., Arlington, VA
Mr. T. Hollinger

Hughes Box and Container Co., Baltimore, MD

Inland Steel, Container Division, Chicago, IL
Mr. [illegible]. Liebaur

Institute of Makers of Explosives, New York, NY
Mr. H. Hampton

J. T. Baker Co., Phillipsburg, NJ
Mr. B. McIlroy

Jacobs Gardner Paper and Chemical Co., Washington, D.C.
Mr. C. Erts

Label Master, Chicago, IL
Mr. H. Fund

Lee Cylinders Division of Golay and Co.
Mr. R. Kinnamin

Legible Signs, Rockville, IL

Linde Division of Union Carbide, Speedway, IN
Ms. G. Henderson

Manufacturing Chemists Association, Washington, D.C.
Mr. M. Hoover

Mobay Chemical Corp., Pittsburgh, PA
Mr. J. Bracco

National Barrel and Drum Manufacturers Association, Washington, D.C.
Mr. M. Hershson

National LP Gas Association, Oak Brook, IL
Mr. W. Johnson

National Motor Freight Carriers Association, Washington, D.C.
Mr. J. Stone

National Safe Transit Association, Chicago, IL
Mr. L. Oppriecht

National Tank Truck Carriers, Inc., Washington, D.C.
Mr. C. Harvison
Mr. A. Rosenbaum

Norris Industries, Los Angeles, CA

Owens-Illinois, Toledo, OH
Mr. M. Brown
Mr. B. Kellow
Mr. S. Parker

Plastic Products Manufacturing Institute, Edelman, NY
Mr. Nash

Pressed Steel Tank Co., Milwaukee, WI
Mr. S. Griggs
Mr. B. Herst

R. S. Willard Co., Gaithersburg, MD

Reynolds Aluminum, Washington, D.C.
Ms. J. Kabernagel

Rheem Manufacturing Co., Linden, NJ

Riley-Beaird, Inc., Shreveport, LA
Mr. D. Carpenter

Southeastern Label and Tape, Inc., Chamblee, GA
Mr. D. Ahern

Steel Shipping Container Institute, Union, NJ
Mr. H. Shappell

Tag and Label Manufacturers Institute, Stamford, CT
Ms. P. Dalziel
Mr. G. Osman

Taylor-Wharton, Inc., Easton, PA

Trinity Industries, Dallas, TX
Mr. H. Lee

Truck Trailer Manufacturers Association, Washington, D.C.
Mr. D. Vierimaa

U.S. Steel, Products Division, Pittsburgh, PA
Mr. D. Bedell
Mr. F. Conforti
Mr. N. Schnaitter

Unz and Company, Jersey City, NJ
Mr. F. Newman

Virginia Packaging Supply Co., McLean, VA

Worthington Cylinders, Columbus, OH
Mr. B. Berman

U.S. Dept. of the Army, Storage and Transportation Division
Mr. Varner

U.S. Dept. of Transportation, Materials Transportation Bureau, Office of Hazardous Materials Operations
Mr. E. Harton
Mr. G. Sononburg

U.S. Energy Research and Development Administration
Mr. B. Brobst
Mr. T. Dunckel
Mr. J. Melaney
Mr. R. Ng

U.S. General Services Administration
Mr. R. Carroll

U.S. Marine Corps, Ammunition/Missile Branch
Mr. Myers

U.S. National Bureau of Standards, Division of Polymers
Mr. J. Barnes

U.S. National Bureau of Standards, Division of Information Technology
Dr. Taylor

U.S. Dept. of the Navy, Naval Surface Weapons Center
Mr. C. Fridinger

U.S. Nuclear Regulatory Commission
Mr. Bartlett
Mr. G. McCorkle
Mr. D. Mathews
Mr. Odegaarden

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